

The Journal of Parasitology

Volume XVI

JUNE, 1930

Number 4

THE WIDE FIELD OF VETERINARY PARASITOLOGY

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In talking to a group of graduate students at a university recently, the writer found that they had never thought of the field of parasitology as dealing with anything other than the morphology and life histories of parasites. This was not surprising, since the writer had no more extensive concept of the subject as a graduate student. Soon after entering the federal service in Washington the writer had a visit from the veteran parasitologist, Dr. Cooper Curtice. Dr. Curtice asked the question whether the writer was interested only in parasites or also in the dear horse, the dear cow and the dear sheep. When the writer replied that he aimed to be a zoologist and was interested in worms and not in livestock, Dr. Curtice informed him that he belonged in a museum and not in the Bureau of Animal Industry. Subsequent events have largely justified Dr. Curtice's contention and the writer has had occasion to enlarge his scope of interests. Just how much they have enlarged is indicated in this paper. The subject of the paper is one that permits of a general survey of its subject and some rambling remarks.

The staff of the Zoological Division of the Bureau of Animal Industry is probably the largest group of parasitologists in the Western Hemisphere, and it follows that numbers of graduate students in parasitology will sooner or later find a place in the division. It may be, therefore, of some interest to such students and their directors of research to know just what qualifications are of value in the work of the division. Aside from the fact that its work does not involve teaching, the scope of work in parasitology is probably greater than that of schools and experiment stations.

Our experience indicates that a parasitologist qualified for the work of the federal service should be familiar, if possible, with all or most of the following subjects: Taxonomy, including a knowledge of the broad classification of the animal kingdom and of the more detailed classification of parasitic groups, and of the Code of Zoological Nomenclature; morphology as a general topic, with a specialized knowledge of the morphology of parasites; the life histories representative of the various possibilities among parasites; pathology; pharmacology and therapeutics;

general prophylactic measures for parasite control; actual agricultural procedures on the farm and ranch, especially as regards grazing and feeding methods; basic training in physics, chemistry, physiology, entomology, and as many related sciences as possible; a reading knowledge, at least, of German, French and Latin, in addition to a sound knowledge of English grammar; a knowledge of bibliographic methods; sound training in laboratory technic; a knowledge of ethics in the professional relations of scientists; and a capacity for hard and dirty work. At the outset we must admit that probably no one of us has all these qualifications highly developed, and that one cannot expect the young student to have them all in any degree. The point, however, is that they are all relevant and that the student may keep them all in mind as things that may concern him, and not consider, as the writer would have done and did at one time, that many of them were wide of the field of parasitology and not worth wasting time in considering.

It might be said more briefly that for preparation in medical parasitology one should have a baccalaureate degree in science, a doctorate in parasitology, and the M.D. degree, or that for veterinary parasitology one should substitute the veterinary degree for the M.D., but such a procedure is not usually feasible and there is little benefit to the parasitologist from many of the courses in medicine. There are certain courses in the medical schools which graduate students in parasitology could arrange to take as minors in some cases if they realized that these courses would be of advantage to them. As matters stand, the set-up in the graduate schools is still predicated, apparently, on the assumption that the graduates will go into the teaching field. True, many of them will, but we urge that the possibility of preparation for other openings be considered.

The trend in the universities in the biological curriculum has been for a number of years away from taxonomy and towards ecology, genetics and other things. Without decrying these other things, one must feel that the neglect of taxonomy is unwise, at least so far as the parasitologist is concerned. A sound taxonomy is helpful in so many respects, and we have so little good classification in the field of parasitology. The flukes are a jumble, the tapeworms are a little better off, and while the nematodes look rather good if one looks only at the nematode parasites of animals or only at the free-living and plant-parasitizing forms, they are a blur so far as the interrelationships of these two groups are concerned. With all of the present blurring in the way of larger groups, it is nevertheless essential for good work that one have a fairly comprehensive idea of these groups if one is to deal with any great efficiency with the hundreds of species of parasites which come to the parasitologist for identification. Even in the matter of

species we are finding too many, especially the common and supposedly well-known ones, to be complexes of species, as has been true for the swine lungworms and nodular worms among others.

Ignorance of the International Code of Zoological Nomenclature on the part of graduates with masters' and doctors' degrees in zoology is altogether too common and is a source of the innumerable synonyms and other nomenclature wastes which drive indexers mad and burden the careful worker. We carry along approximately one dead generic name for every valid name among the nematodes. Every graduate student should be required to pass an examination on the code and know it well enough to avoid creating stillborn homonyms and synonyms when all the facts are actually before him. Some of our most respected, beloved and competent colleagues create groups which do not fit into any recognized code or usage, but the student cannot afford to do these things.

In this connection, two general ideas might be urged. One is that we go lightly in proposing new genera and in resurrecting old and disused ones. In general, our taxonomic system is a filing system and we are warranted in considering the matter of convenience. If a genus has only two or three species in it, and a generic diagnosis can be written which clearly separates that generic group from all others, it seems advisable to leave the genus alone even if there are grounds on which it can be split into several genera. On the other hand, if a genus has a hundred species, one is justified in selecting almost any reasonable character as a basis for splitting the group. In other words, given a hundred species in one genus or a hundred genera with one species each, the labor of identification in this group involves a consideration of a hundred units, whereas with a group of 100 species arranged as ten genera with ten species each, the labor of identification involves a consideration of ten genera and ten species, or twenty units. This may seem a bit academic, but it is not academic to the systematist who has to make hundreds of identifications.

The writer concurs with Stiles in the belief that taxonomy is mostly subjective. Even our most definite unit, the species, is debatably a reality or a concept. Nature provides us with animals, but we create our own genera. Let us use discretion in the exercise of the function of the demiurge. As regards the business of examining old and forgotten generic names to supplant those in use, the writer has indulged in this sport in the past but has come to the conclusion that it is a bothersome and unprofitable business. He favors the selection of a large official list or list of *nomina conservanda*, especially for forms of medical or economic importance, and would extend this list to species as well as genera. We have recently had a new name proposed for a nomen con-

servandum in helminthology, and in this connection he would suggest that we consult the present list before changing names.

Along the line of nomenclature, I note with regret a lot of changes recently made by purists who insist on applying their ample knowledge of Greek and Latin to zoological names. In some of these cases our long-established generic terminations in *us* are changed to *a* or *um* and all specific names changed to correspond; in others the established family names in *idae* are changed to *atidae*. In such cases the writer believes that we are warranted in applying the rule of priority over that of emendation, and refusing to upset our literature. The fact is that most of us are none too sound on Latin after four years' exposure to the subject and that most of us are almost entirely ignorant of Greek. The writer subscribes to Dr. Hassall's definition of a scientific name as "a collection of letters and no damn other thing," and feels that if we should adopt the rule of taking them as they stand regardless of classical precision it would do no harm. What we need is stability even at the sacrifice of classical accuracy.

There is one other thing which should be urged in connection with taxonomic papers. Dr. L. O. Howard campaigned for years to get entomologists to put in the titles of their papers the order and family to which the insects discussed belonged. It is time we did something of the sort in parasitology. The number of genera is becoming entirely too large for anyone to expect to keep in mind the relationships and groups among the parasites or to recognize the position of a genus by a glance at the generic name. The good old days when all strongyles were *Strongylus*, all ascarids *Ascaris*, all spirurids *Spiroptera*, all filarids *Filaria*, all tapeworms *Taenia*, and all flukes *Distomum* or *Monostomum*, are gone forever. The least we should ask of anyone today is that when he proposes a new genus he indicate definitely where it belongs at least as regards its family. If he doesn't know this, just how does he know he has a new genus anyway? If he knows this, why expect his readers to hunt up the information? I can speak feelingly on this subject for the reason that I have attempted to edit abstracts for Biological Abstracts, and only the exceptional paper conveys this information. Usually it is necessary to study the description and make an assignment to a family, and while this should be easy for the person proposing a new genus, it is a painful matter for the person who is compelled to run down dozens of descriptions in the limited time which is available for such an avocation as editing. Editors of journals publishing papers on parasitology would confer a favor on their colleagues if they would refuse to accept papers proposing new genera without discussing the family status of these genera.

It is probably unnecessary to say much about morphology, as it usually receives attention in the schools. However, in a recent examination in parasitology a surprising number of representatives of colleges where parasitology is taught or in which graduate work is given, revealed a belief that the distome acetabulum and the cestode suckers were used to take in nourishment, and perhaps a little more of the parasite physiology should be given. As regards morphology the writer has had the glands of the cecal mucosa and Peyer's patches pointed out to him as lesions by young workers, and thinks that the student of parasitology should be familiar with the normal appearance of the digestive tract. Of course, if he isn't when he graduates he will be after he has worked in a laboratory of veterinary parasitology for a year. It is likewise unnecessary to speak of the subject of parasite life histories. Their many bizarre forms make the subject of parasitology at once fascinating and difficult, and they receive attention accordingly.

Graduate students rarely have any knowledge of pathology, but this subject is one of the most important for the medical or veterinary parasitologist, and whenever possible these students should take a course in pathology as a minor. It seems obvious that one would want to know what the parasite does to its host, and unless one has some concept of the mechanism of pathology such terms as inflammation, anemia, edema, ascites, hematuria, and the like are merely words to be memorized, when they should be processes which follow logically from the known habits of the parasite in relation to its host.

Pharmacology and therapeutics are less important than pathology, but the student who might enter a laboratory of medical or veterinary parasitology would find it of value to know some of the basic principles underlying the treatment of parasitoses and something of the reactions of parasites and hosts to drugs. The subject of anthelmintic medication is one on which the writer has spent about 14 years. It has barely opened up as a field for research and all of the really important work remains to be done.

The subject of prevention of parasitisms receives some attention in our schools, and probably deserves more. It would not be a bad form of examination for students to give them sample life histories of all sorts of parasites in all sorts of hosts and ask them to select the weak link in the life cycle at which one might drive and propose a method of driving at it. This is precisely the end to which all the work of the Zoological Division aims, and the formulation of control measures ultimately falls to the lot of all its staff. We all know that some schools approve of pure science only and disapprove of applied science. It is a good thing that schools should work in pure science, but, practically

speaking, parasitology is one of the applied sciences and any comprehensive grasp of it involves a knowledge of its application.

Most graduate students will probably look askance at the idea that a knowledge of farming methods is of value to a parasitologist, but the farm and ranch are the battlegrounds on which the decisive battles for the control of livestock parasites must be fought, and the combatant must know his terrain. Not only the nature of the terrain, but also the customary activities on it must be known. These will vary from time to time and from place to place. To know them at all well one must travel and see them. This procedure cannot be required of the student, and it is fortunate that for the purposes of the federal government it is necessary that those who are engaged in the control of livestock parasites shall survey the field of action in the course of official business in many cases. However, the young worker and student should regard livestock, forage crops, pastures and related topics as subjects which may concern him as a parasitologist. A profound ignorance of farming may some day limit his usefulness as a parasitologist.

It is useless to dwell long on the subject of basic training in the physical, chemical and biological sciences. To the writer's horror, he finds that one should even understand mathematics if he would employ biometric methods. Every gap in one's knowledge of these things is a limitation and a handicap. The student who has to take courses in these subjects is more fortunate than he is aware, while the victim of electives who avoids these subjects will sooner or later realize that he is out of luck. However, one might note that a large field is opening up in problems dealing with the relations between parasites and food, parasites and vitamins, parasites and the ductless glands, parasites and bacteria, and other relations, and that broad preparation is essential for the investigations. Chemistry is essential for research in chemotherapy, still a new field with many possibilities.

Entomology is such a large subject that the study of the Insecta and Arachnida in general courses in zoology is not adequate. Both as parasites and intermediate hosts of parasites these arthropods are too important for this, and one should have at least a general course in entomology, even if only for background.

What has just been said of the basic sciences applies with equal force to languages. Doubtless all of us have seen candidates for the Ph.D. degree sweating under the protests of the language department against the conferring of the degree on persons so deficient in languages, or seen the young investigator going to night school or some similar agency to acquire the languages so essential to anyone who would know what the world is doing or has done in his field. Four languages, English, French, German and Latin, may be regarded as minimum essentials.

With these one can learn enough Spanish, Portuguese, Italian and Dutch to solve scientific papers on parasitology in these languages. If life were longer, one could use Russian, Hungarian, Arabic, Japanese and other languages, but life is not that long. We can only ask our confreres who publish in these languages to append summaries or abstracts in some romance or teutonic language, and trust to their appreciation of the situation to do so.

It may be said that we must not ask too much of our students, but is it asking too much that they know the rudiments of grammar and that they be able to spell English words? The recent crops of graduates were frequently products of the era which taught reading by sight, and they never worried through the "c-a-t, cat" epoch; as a rule they can read, but they can't spell. Why they use singular verbs with plural subjects is not clear; it may be chargeable to a pedagogical method or to individual idiosyncrasy. In one capacity or another the writer reads from one to two thousand pages of manuscript a year, and finds in these papers a surprising lot of errors of a sort that should be corrected by the author when he reads his manuscript.

Experience indicates that the graduate student should be taught that there are "57 varieties" of ways of making up bibliographies and of citing references, and that the general rule is that the editor of a publication will settle the practice in this regard for all papers published in his journal. An appreciation of this fact will save the student from going through the ancient row with the editor in an attempt to get the editor to change his habits. In the long run one learns that editing is an editor's business, but why not explain this to the student? This would save his energies for the job of preventing the editor from changes that violate the code of nomenclature, the facts in the case, or the rules of grammar.

The methodology of science is probably a moot point in academic circles; in the writer's experience this matter is a very painful subject. It often happens that the young M.A. or Ph.D., who enters the Zoological Division is blissfully ignorant of the basic methods of experimental research. He does not understand how to set up an experimental attack on a problem; he is unaware of the need for checks and controls; he cannot balance the factors not involved in an experiment in order to vary the factors involved with some likelihood of obtaining significant results; he does not appreciate the need for sufficient data to offset experimental error and chance variation; he does not know how to draw conclusions which are warranted by the data, and he must be headed away from *post hoc, ergo propter hoc* reasoning. This state of affairs results largely from the belief of many directors of research that the graduate student should be thrown into a problem and left to sink or swim, a belief which the present writer does not share. The methods

of research can be and should be taught, precisely as bricklaying is taught. There may be some such thing as research ability as an art, but research in general is a scientific method of procedure which can and should be taught. If the director of research in the schools doesn't teach it, the student's director elsewhere will have to teach it, but he will have the impression that the schools are neglecting their duty, which is to direct research, not to start it and let it direct itself.

The necessity for a sound training in laboratory technic is obvious, and this should not consist only in a knowledge of how to make toto mounts and sections. Parasitology is developing its own technical methods and the student should learn how to make a fecal examination by the various sedimentation, levitation and sampling methods, to make a satisfactory post-mortem examination, to use the Baermann apparatus in collecting small worms from soil, feces or intestinal contents, and to prepare skin scrapings for mange parasites. It is not enough to know what methods are used; the student should be taught that these methods can be improved. We still need a good preservative for specimens in place of alcohol, always a fluid which evaporated too fast in pre-prohibition days and now a nuisance because of the need for lock and guard to prevent theft. We still need a satisfactory medium for toto mounts of nematodes, and one for parasite eggs.

The need for a knowledge of ethics in the professional relations of scientists is a real one. All of us recall cases in which callow students have put out theses filled with scorn at the errors or supposed errors of distinguished workers many years their senior; all of us know of cases where publications have ostentatiously omitted credits for ideas and phrasing which might better have been credited. Most of us outgrow in time the childish habit of calling names, but the student might well be advised not to start the habit. The student should be taught that giving credit is sharing responsibility. He should learn that the courteous things of life are not only pleasant things, but that if that idea alone doesn't appeal to him, they are also profitable. One is not really of the fellowship of parasitologists until he is established among his fellows on a basis of mutual courtesy. The Helminthological Society of Washington has no constitution or by-laws, but it does have a code of ethics. A copy should be posted in every zoological laboratory, especially where there are graduate students. It would be thoroughly worth while for every student of parasitology to familiarize himself with it. A certain gentleness and consideration in writing of other authors, and a punctilious acknowledgment of specimens loaned, identifications made, and similar courtesies, make for good feeling and cooperation. If one must indulge in discourtesy or a vendetta, he should make it a private fight—by correspondence, verbally or pugilistically—but not drag it into a scientific publication; it is not a contribution to our knowledge of science.

As a final qualification for the parasitologist we list* a large capacity for hard and dirty work. Fecal examinations are essential to many kinds of investigations in parasitology. Post-mortem examinations are the special occupation of the collector, and collecting is usually the first move in our studies. It is easy to make a collector of an A.B., it is possible to make one of an M.A., but it is difficult to make one of a Ph.D. The Ph.D. is usually too academic minded or too dignified. For the purposes of a laboratory of veterinary parasitology, as for the army, it is better to "catch 'em young and treat 'em rough." One may have to make a post-mortem examination of a horse on a prairie in a snow storm, or of a much too dead sheep in a stuffy room in the heat of August, or of a snake which comes to hand on a walk through the woods. Only an insatiable curiosity in one's subject matter, an unwillingness to abandon an opportunity because of discomfort, and an inability to be satisfied with an inadequate examination will hold one to one's task under all these conditions, but of such qualities and such material is much of the structure of parasitology built. The person who shrinks from blood or dirt, who pokes at a specimen and reports it in too poor condition to examine, who quits when he has found the obvious and self-evident things, and who is easily satisfied, lacks the heart and mind for work in parasitology. Much of our work is mucky work, and only real workers qualify for it.

This paper is not intended to criticize schools, directors of research, or students. It is intended to present a point of view which may not be familiar in all its aspects in college and university circles. There are certain tasks in the way of training students which could be done to better advantage in the schools than in government laboratories, and these matters are receiving inadequate attention. It is assumed here that the need for these things is not understood, and that if it were understood the matter would receive attention. There are certain subjects which experience has shown to be valuable, but with which few students are familiar and these are noted here as information. Finally there are certain personal qualities and habits which qualify one for the friendly fellowship of the parasitological fraternity, and these things should be brought to the student's attention.

In view of the fact that the Code of Ethics of the Helminthological Society of Washington has been published only twice and may not be readily available to those who might wish to consult it, the code is appended here.

1. Adverse discussion of the work of another scientist should be impersonal. Any disagreement with the statements of any other writer should be expressed in terms of disagreement with the statements only and should not be expressed in a manner likely to reflect upon his competence or intelligence.

2. When specimens are examined by two or more persons with a distinct understanding or a definitely implied agreement as to publication, whether jointly or independently, the terms of the understanding or agreement should be observed as rigidly as in any contract.

3. When specimens are examined by two or more persons, as when specimens are referred by collectors to systematists, all persons concerned may retain the right of independent publication in the capacity in which they act.

4. In correspondence or conference, statements of new and unpublished findings are to be regarded as privileged communications and no persons should publish information thus first obtained unless properly authorized to do so.

5. The general rule covering co-operative activities is that the greatest possible courtesy should be observed by all persons at all times. In general it is not proper for a collector to request a systematist to determine whether an unstudied specimen is new or not and then, if determined as new, to claim the right of description for publication; but where it is desirable that material be compared with certain type specimens, the right of description may be retained by the collector, preferably by definite agreement with the person making the requested comparison with type material.

6. As recommended by the International Zoological Congress, persons noting that homonyms of existing species or genera have been published by a writer should refer the matter to the author, notifying him of the homonym. It is here considered the duty of the author of the homonym to propose a substitute name immediately and to publish it promptly, at the latest within a year from the receipt of such notification. After one year or at the suggestion of the author that someone else propose a new name, it is here considered proper for anyone to propose a new name.

7. The transfer of a species from one genus to another, one family to another, etc., is properly within the province of any writer without referring the matter to the author of the names involved; such transfer is a matter of individual opinion and the acceptance or non-acceptance of the combinations arrived at is a matter of consensus among zoologists.

8. In general, authors should avoid in their publications anything which shall seem to claim as original, ideas, discoveries or illustrations which are not original with them. For many generally or long known facts it is often obviously unnecessary or impossible to cite authority; it is, however, possible to avoid writing in a manner which seems to claim credit for subject matter or wording for which the credit belongs to another.

9. An official or superior should not take advantage of his position in connection with any publication resulting from work performed by his students or assistants, even when they are working under his immediate direction. Conversely, students, assistants and others should respect their obligations to their official superiors and colleagues.

10. When called into professional consultation by a practicing physician, an active member of this society should govern himself by the Principles of Medical Ethics adopted and published by the American Medical Association.

11. When called into professional consultation by a practicing veterinarian, an active member of this society should govern himself by the Code of Ethics adopted and published by the American Veterinary Medical Association.

12. In case of war, epidemic or epizootic, in which technical zoological knowledge is of practical importance to the public authorities, zoologists should consider themselves at the service of such authorities, whether federal, state or local.

13. A zoologist should acknowledge the right of an editor to edit copy in harmony with the established editorial rules of his journals, in so far as language and typography are concerned. In matters of fact and nomenclature, namely, Latin systematic names, the author is considered to have the right of final decision.

AN EXPERIMENTAL STUDY OF THE BEHAVIOR OF
CERCARIA FLORIDENSIS IN RELATION TO ITS
FISH INTERMEDIATE HOST *

H. M. MILLER, JR., AND O. R. MCCOY

The behavior of larval trematodes in the presence of their intermediate or definitive hosts has been studied in only a few instances. Most investigators agree that cercariae are not attracted chemically to the host. The penetration reactions of several species of cercariae have been studied (Wunder, 1923; Faust and Meleney, 1924; Szidat, 1925; Faust and Khaw, 1927). Wunder demonstrated that the photonegative reaction of *Cercaria intermedia* and its intermediate host brought them together, when in shallow dishes, and facilitated infestation. The present study deals with the possible chemotactic reactions and penetration of *Cercaria floridensis* McCoy (1929), with the longevity and infectivity of the cercaria under experimental conditions, and with infestation under different conditions of light. It is essentially an inquiry into the adaptive value of the behavior of this larva.

Cercaria floridensis, a small lophocercous form with pigmented eyespots, was first found infesting *Cerithium litteratum* at Tortugas, Florida; it was temporarily designated *Cercaria P* of Tortugas and its behavior and reactions studied by Miller (1926, 1927). Subsequently, McCoy (1928) found it to develop to the metacercarial stage in small fishes. It penetrates the integument and encysts under the scales and in the fin rays, seldom in the thin tissue between the dorsal spines and rarely, if ever, in the muscles. Typical echinostome spines develop during the metacercarial stage; the adult stage is unknown.

Only highly reactive cercariae were selected for the experiments. Infested gonads were teased apart in shallow petri dishes and the most active cercariae were concentrated at the light side of the dish by stimulating them repeatedly with short shadows. Numerous cercariae, in small quantities of water, were pipetted into a cylinder, from which 5 cc. portions of an even suspension were withdrawn and transferred to the containers in which the fish were exposed to infestation. It was found that this process did not cause the cercariae to lose their tails. The number of cercariae in a 5 cc. sample was estimated by counting those in two 0.5 cc. samples. Different lots of cercariae showed variation in infectivity, but only those from one lot were used in a single experiment.

* From the Department of Zoology, Washington University, St. Louis, and the Department of Helminthology, Johns Hopkins University. The work was done at the Carnegie Marine Biological Laboratory, Tortugas, Florida.

More than 350 fish were used. These were small yellow grunts, *Haemulon sciurus*, which had been found to be a natural, non-specific intermediate host of *C. floridensis*. The average size of these, measured from the anterior tip to the base of the caudal peduncle, was 45 mm., and they ranged from 33 to 63 mm. Very few of the extreme sizes were used, and it may be stated that in these experiments no correlation was found, statistically, between the size of the fish and the number of encysted cercariae. As the cercariae encyst under the scales and in the fin rays the only practical method of determining the degree of infestation is to count the number of cysts in the various fins: caudal, dorsal, anal, pectorals and pelvics. It is believed that a fair sample is obtained by this method, as the combined surface area of the fins is, by careful estimation, more than one-third of the total surface of the fish exposed to infestation. The fish were kept 12 hours or more after infestation, by which time the cercariae had encysted; the fins were clipped off, placed in water in numbered petri dishes, and the cysts counted by the aid of a binocular dissecting microscope. They were easily visible and readily distinguished from the very few natural infestations found. All counts were made by one of us, who did not know from which experimental lot the fish were taken. The fish were exposed to infestations in clear glass aquaria, 22 cm. in diameter. In experiments 4 to 6 these contained 5 liters of water, to a depth of 150 mm. In experiments 5 and 6 the fishes were confined to the upper or lower third of the aquarium by means of galvanized wire screens.

BEHAVIOR AND REACTIONS OF THE CERCARIA

Cercaria floridensis is strongly photopositive. Upon emergence from host tissue it swims by a series of short dashes toward the region of greatest illumination and remains there. Swimming is intermittent. A short rapid dash, generally upward and with body in advance, alternates with a period of passive sinking. Both the initiation of swimming and the cessation are most abrupt, and the rate of locomotion is very rapid. Upon cessation of swimming a characteristic shape is quickly assumed; the tail is bent in a sigmoid curve at right angles to the contracted heavy body, which eventually hangs below it during sinking. The cercaria may be instantly activated to swim upward, either while sinking or while resting on the substratum, by casting a shadow upon the container. If the shadow is of short duration (less than two seconds) the path of the latter part of the swim is changed abruptly so that the cercaria progresses toward the light side of the container. Advantage was taken of this reaction in the collection of the cercariae for experimental use. *C. floridensis* may also be instantaneously stimulated to swim upward when touched by an instrument or by an active individual. Judging

from the results of the experiments to be described, this upward swim may carry the cercaria into the neighborhood of the fishes casting the shadows and thus facilitate infestation.

The cercariae when just emerged from host tissue do not swim to the surface of the water and remain near there for a time, as do some other species which are intermittent swimmers. But provided the light comes somewhat from above, a considerable percentage of the cercariae may, even in the laboratory, be generally distributed throughout the container and appear as a "suspension," although many remain near the bottom. In the dark the cercariae are more concentrated in the lower levels of the water. This difference in vertical distribution in the light and in the dark accounts in part for the results obtained in the last series of experiments described in this paper.

The behavior of *C. floridensis* in the presence of the fish intermediate host and its reactions in penetrating the integument were studied with the aid of a binocular microscope. Cercariae were added to a watch glass containing a small immobilized fish or a fish tail, and the behavior of the larvae on the transparent caudal fin observed. Many of the cercariae which sank onto the fin swam upward from it repeatedly, even after crawling about for some time; some were caught in the mucus and immediately dropped their tails and started to bore into the fin, while others shed their tails at varying intervals afterwards; some did not start the boring movements until more than 20 minutes after becoming entangled.

In the penetration reactions the body suddenly contracted, swelled in the region posterior to the eyespots to about one and one-half times the diameter of the extended body, and then a wave of contraction passed posteriorly until the body was fully extended. The first contraction, that which shortened the body, was the more rapid of the two. Sometimes the tail would jerk quickly once or several times, bending as it did so (or if already bent, the movement appeared to be a twisting, boring one); or the tail would lash vigorously for a period of more than six seconds. The tail did not lash or bend regularly at any particular point in the cycle of contractions of the body. At other times the body anterior to the eyespots went through rapid contractions and extensions, while the rest of the body changed shape little, if at all. These movements no doubt served to bury the retrorse spines on the anterior end of the body into the soft integument; they may also be concerned with the pouring out of the secretion of the penetration glands. The same series of reactions was observed with fish scales; the cercariae encysted in the tissue adhering to the scale. In a number of instances cercariae which had been exhibiting typical boring reactions shook themselves free from the integument of the fish and swam away when a shadow was thrown upon them.

The fish showed evident signs of irritation due to the penetrating cercariae when placed in water containing relatively large numbers of larvae and compared with fish in plain water. These consisted of jerky movements of the body and tail, but were not accompanied by frantic swimming about the container. No differences in the behavior were noted after the fish had been exposed to the cercariae for a period of an hour. Several experiments were carried out to test the reactions of the cercariae to the mucus and body fluids of different animals. Small pieces of feather, which is semi-transparent and easily manipulated, were smeared with mucus from a grunt fish, a medusa (*Cassiopeia*) a conch (*Strombus*), and with human saliva, and were placed separately in watch glasses to which were added approximately equal numbers of active cercariae; pieces of unsmeared feather were used as controls. The cercariae in the control dishes never exhibited any penetration reactions, but particularly in the case of the feather smeared with fish mucus, and to a lesser extent that with saliva mucus, the typical reactions were observed. The cercariae became entangled in the medusa and conch mucus, but in the latter case no tails were dropped and no boring movements were ever observed.

In another series of experiments mucus from the integument and expressed tissue fluids of three species of fishes, mucus from a medusa, from a conch, and from human saliva, were mixed with agar and with gelatine, and poured into small salt cellars. When solidified and cooled about 20 cercariae were added to each. No typical penetration reactions were observed. In other experiments cercariae were added to the fluids obtained by teasing the muscle of various fish in a small amount of sea water and squeezing the mass through several layers of cheese cloth. Observations were made after 5, 30, and 120 minutes. In no case did a considerable percentage of the cercariae shed their tails, or undergo any reactions which would suggest that they were stimulated by the fluids. The results of these experiments indicate that the cercariae are not strongly attracted, if at all, to the fish intermediate host, most certainly not from even a short distance; and that the entangling factor seems to be the important one in the penetration behavior.

LONGEVITY AND INFECTIVITY

The statement is commonly made that the length of life of a larval trematode which does not encyst or reach a host is less than 48 hours, but no quantitative studies have been made, under experimental conditions, of their longevity and infectivity. Three experiments, the first a preliminary one, were carried out with *C. floridensis* to determine how long the cercariae would live under experimental conditions and still retain their ability to infest the fish host. Approximately equal numbers

of cercariae were added to aquaria which were covered with glass plates and placed in a water table, the temperature of which did not vary more than 2 C. As the experiments extended over more than 24 hours, all exposures of the fish to the cercariae were made in a darkroom to eliminate the factor of shadows which activate the cercariae. Accordingly, at the end of two hours and at suitable intervals thereafter an aquarium was removed to a darkroom, and after a 10-15 minute period of dark adaptation of the cercariae the fish were placed in it without stirring up the water. The exposure time in each trial was one hour.

TABLE 1.—*Infectivity of Cercariae at Various Ages*

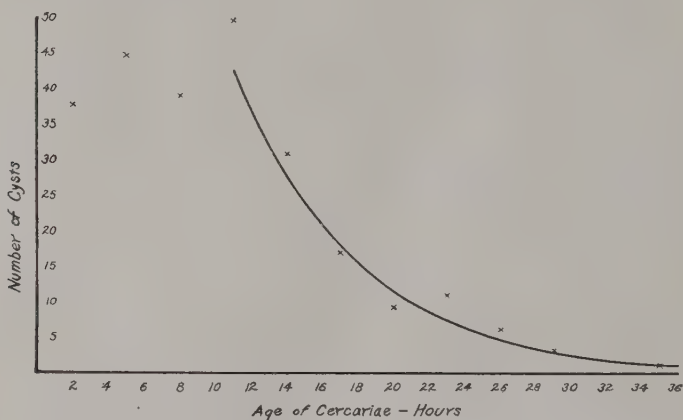
Exp. 1. Figures are average number of cysts in 10 fish, exposed to 2600 cercariae in 2000 cc. of water for one hour						
Age of Cercariae in Hours	Location of Cysts in Fins					Average Number of Cysts per Fish
	Pectoral	Caudal	Pelvic	Dorsal	Anal	
2-3	10.4	11.6	4.8	4.0	2.4	33.2 ± 1.6
12-13	9.7	7.3	3.3	2.5	1.5	24.3 ± 1.7
22-23	0.8	0.5	1.3	0.1	0.1	2.8 ± 0.4
32-31	0.3	0.0	0.0	0.0	0.0	0.3 ± 0.3
Exp. 2. Average number of cysts in 10 fish, exposed to 1100 cercariae in 2000 cc. of water for one hour						
2-3	3.3	2.2	2.4	1.6	0.8	10.3 ± 0.6
8-9	3.2	3.0	3.4	1.7	1.0	12.3 ± 1.3
13-14	1.9	1.8	1.4	1.1	0.6	6.8 ± 0.5
17-18	1.1	0.6	1.1	0.1	0.1	3.0 ± 0.3
21-22	0.6	0.1	0.6	0.1	0.1	1.5 ± 0.2
25-26	0.2	0.0	0.3	0.0	0.1	0.6 ± 0.1
Exp. 3. Average number of cysts in 8 fish, exposed to 3200 cercariae in 1000 cc. of water for one hour						
2-3	11.6	10.6	7.7	5.0	2.8	37.7 ± 2.0
5-6	16.6	8.8	10.1	5.3	3.9	44.6 ± 4.4
8-9	16.7	7.6	7.3	3.3	3.6	39.0 ± 2.4
11-12	19.5	13.1	10.2	3.3	3.4	49.5 ± 3.9
14-15	13.6	9.4	4.5	1.5	1.8	30.8 ± 4.6
17-18	5.8	3.3	5.3	1.9	0.8	16.9 ± 1.2
20-21	2.8	0.4	5.1	0.3	0.6	9.1 ± 0.7
23-24	2.8	1.4	5.5	1.0	0.3	10.9 ± 0.9
26-27	2.1	0.5	2.6	0.6	0.3	6.1 ± 0.7
29-30	1.5	0.3	1.1	0.1	0.1	3.1 ± 0.4
35-36	0.3	0.1	0.4	0.3	0.0	1.0 ± 0.2

The age of the cercariae was reckoned from the time that the host tissue was teased apart and the larvae liberated. All figures recorded as "cysts per fish" are the total number of cysts counted in the seven fins.

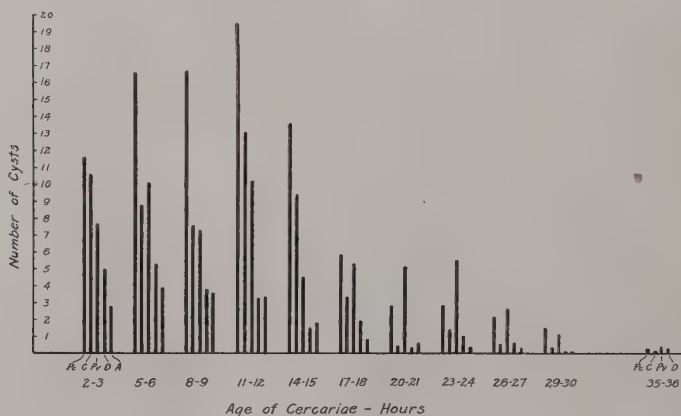
Experiment 1. Approximately 2600 cercariae were added to each of 4 aquaria containing 2 liters of water with a depth of 60 mm. Ten fish were added to one aquarium when the larvae were 2 hours old, and to each of the others in turn after 12, 22, and 30 hours. The average number of cysts per fish produced as a result of these exposures was 33.2 ± 1.6 , 24.3 ± 1.7 , 2.8 ± 0.4 and 0.3 ± 0.3 , respectively, showing that under the conditions of the experiment the cercariae did not live much longer than 30 hours.

Experiment 2. Fewer cercariae were available for this experiment; approximately 1000 were added to 2 liters of water in each of 6 aquaria, and 10 fish were placed in them in turn at the end of 2, 8, 13, 17, 21,

and 25 hours. The resulting average number of cysts per fish was 10.3 ± 0.6 , 12.3 ± 1.3 , 6.8 ± 0.5 , 3.0 ± 0.3 , 1.5 ± 0.2 , and 0.6 ± 0.1 , respectively. The infectivity did not decrease as rapidly in this as in the first experiment.



Text-figure 1.—Graph of data of Experiment 3, showing the average numbers of cysts in the fins of 8 fish exposed to infestation by cercariae of different ages.



Text-figure 2.—Bar diagram showing numbers of cysts in the fins of fish exposed to infestation by cercariae of different ages. Fins in order, from left to right, in diagram: pectorals, *Pc*; caudal, *C*; pelvics, *Pv*; dorsal, *D*; anal, *A*.

Experiment 3. (Text-figures 1, 2). Larger numbers of cercariae were available for this experiment and they were placed in aquaria containing 1 liter of water instead of 2 liters as in Experiments 1 and 2. Eleven aquaria were used, each with approximately 3200 cercariae and 8

fish. It was necessary to reduce the number of fish per aquarium from 10 to 8 because in the smaller amount of water the fish would have suffered from an insufficiency of oxygen before the end of the exposure period. The first exposure was made when the cercariae were 2 hours old, and the succeeding ones at 3 hour intervals, except the last, which was made 6 hours after the tenth one. The resulting average number of cysts per fish showed that approximately the same degree of infestation was obtained until the cercariae were 11 hours old, indicating that there was no loss in ability to infest the host up to this time. After 11 hours the curve of infestation dropped rapidly until at 35-38 hours an average of only one cyst per fish was present. Examination of the cercariae in this aquarium, after the fish had been removed, showed that most of them were decaudated and some were creeping upon the bottom. These were presumably able to infest the fish, but being decaudated lacked the means of reaching them, except possibly in case of a fish which was resting with pelvic fins on the bottom.

To determine the rate at which the infectivity of the cercariae decreased an exponential curve was fitted to the data obtained in Experiment 3. This curve is represented by the formula $y = ab^x$ where y is the number of cysts, x is the age of the cercariae in hours, and a and b are constants. The curve was fitted graphically by plotting the values of x and y on arith-log paper and determining the best fitting straight line by inspection. The constants of the equation and the points on the curve were then calculated from values of x and y taken from this line. Since the data did not indicate any significant change in infectivity up to 15 hours, the four observations previous to this time were combined to give an average value for the infectivity at age 11 hours. The exponential curve fitted reasonably well the observations from this point on. The b constant of the curve is 0.86726, indicating that the infectivity of the group of cercariae decreased approximately 13 per cent. per hour.

INFESTATION OF FISH UNDER DIFFERENT CONDITIONS OF LIGHT

As *C. floridensis* is very sensitive to shadows, being frequently activated to swim upward when even so small an object as a pencil is passed between the light source and the container, experiments were planned to determine whether the infestation in the light would be greater than that of fish kept in total darkness. It was thought possible that cercariae might be activated by the shadows cast by fish swimming above them, and that this reaction might bring the cercariae into the immediate neighborhood of the fish and thus aid in infestation. Actually, it was found that the difference in distribution of the cercariae in light and in dark was a more important factor. The results of three experiments are described below (Table 2).

Experiment 4. Six aquaria, each containing approximately 1800 cercariae and 3 fish in 5 liters of water with a depth of 150 mm., were placed in strong diffuse daylight outside of the laboratory on the white coral sand and 6 were placed in a darkroom; the exposure time was 3.5 hours. The fish were not confined to any part of the aquaria, but for the most part they remained swimming quietly close to the bottom. By means of a weak red light observations were made from time to time of the behavior of the fish in the darkroom, but no significant differences were noted between them and the fish in the light.

TABLE 2.—*Numbers of Cysts in Fish, Ranging Throughout Container and Confined at Different Levels, When Exposed in Daylight and Darkness*

Exp. 4. Fish allowed to range throughout aquaria during exposure. Figures are average numbers of cysts in 18 fish, exposed in 6 aquaria each containing 1800 cercariae in 5000 cc. of water							
Condition of Exposure	Location of Cysts in Fins					Average Number of Cysts per Fish	Difference and Its Probable Error
	Pectoral	Caudal	Pelvic	Dorsal	Anal		
(a) Daylight.....	21.6	16.9	2.6	5.4	2.6	49.1 $\pm$ 1.6	15.4 $\pm$ 3.5
(b) Darkness.....	26.0	19.4	8.3	7.0	4.0	64.6 $\pm$ 3.1	
Exp. 5. Fish confined in upper and lower levels of container, under both conditions of illumination. Figures are average numbers of cysts in 20 fish, exposed in 4 aquaria each containing 2200 cercariae in 5000 cc. of water							
Fish in upper level							
(a) Daylight.....	3.3	2.0	0.8	0.5	0.7	7.3 $\pm$ 1.0	3.7 $\pm$ 1.1
(b) Darkness.....	1.6	1.1	0.3	0.4	0.1	3.6 $\pm$ 0.6	
Fish in lower level							
(c) Daylight.....	10.9	8.9	3.1	2.3	1.7	26.8 $\pm$ 1.8	11.0 $\pm$ 2.6
(d) Darkness.....	14.1	11.5	7.1	2.3	2.8	37.7 $\pm$ 1.9	
Exp. 6. Fish confined in upper level. Figures are average numbers of cysts in 25 fish, exposed in 5 aquaria, each containing 3000 cercariae in 5000 cc. of water							
Daylight.....	2.6	2.8	0.5	0.9	0.3	7.0 $\pm$ 1.0	6.5 $\pm$ 1.0
Darkness.....	0.1	0.1	0.1	0.2	0.1	0.5 $\pm$ 0.1	

The average number of cysts in the fish in the light was found to be 49.1 ± 1.6 and that in the fish confined in the dark was 64.6 ± 3.1 ; the difference between the two means is 4.4 times the probable error of the difference, and hence is statistically significant. As the behavior of the fish under the two conditions of illumination was essentially the same, the different degrees of infestation can only be explained on the basis of the behavior of the cercariae. These are never evenly distributed throughout a container or concentrated at the surface as are the larvae of some species of trematodes. While the cercariae continue to swim spontaneously in the dark, more tend to remain in the upper levels of the container when they are in the light. This is particularly true in the case of strong light coming from above. In view, then, of the fact that the fish under both conditions remained in the lower part of the aquaria and that the cercariae were probably more concentrated

near the bottom of the aquaria in the darkroom, it is not surprising that the fish which were in total darkness became more heavily infested.

Experiment 5. The fish used in this experiment were again exposed to infestation under the conditions of strong daylight and total darkness, but instead of being allowed to range throughout the aquaria they were confined in the upper or lower thirds. This was accomplished by the aid of circular pieces of galvanized wire screen having 2.5 mm. square openings. The fish swimming in the upper third of the aquaria in the light cast many shadows on the cercariae below, and it was felt that the comparison of the infestation of these fish with those which were similarly confined and were exposed in the dark should show whether the reaction to light was playing a rôle in the infestation, under the conditions of the experiment. Sixteen aquaria, each containing 5 fish and approximately 1700 cercariae, were used, 4 under each condition of exposure, the duration of which was 3 hours.

In the case of the fish which were confined in the lower third of the containers there was again a significantly higher average number of cysts in the fish which had been in the dark. In the latter an average of 37.7 ± 1.9 cysts was present, and in the fish in the light an average of 26.8 ± 1.8 ; the difference between the two means is 4.2 times the probable error of the difference (table 2). This may again be explained by the fact that more cercariae were distributed in the higher levels of the containers in the light and hence fewer were likely to come in contact with fish in the lower third.

Considerably fewer cysts were present in the fish which had been confined in the upper third of the aquaria. But in the fish exposed to infestation in the light an average of 7.3 ± 1.0 cysts occurred, while an average of 3.6 ± 0.5 was present in the fish in the dark; the difference is almost certainly significant, being 3.36 times its probable error. This may indicate that the higher distribution of the cercariae in the light, and their activation to swim upward in response to shadows cast by the fish, are the factors which brought about the greater infestation in the fish exposed in the light.

Experiment 6. As the part of Experiment 5 in which the fish were confined in the upper part of the aquaria is the more critical test of the possible rôle played by shadows in the infestation of the grunt, it was repeated on a slightly larger scale. Ten aquaria, each with 5 fish and approximately 3000 cercariae, instead of 8 aquaria and 1700 cercariae as in Experiment 5, were used and the fish similarly exposed for 3 hours. In the fish exposed in the dark an average of only 0.5 ± 0.1 cysts was present, while in the fish in the light there was an average of 7.0 ± 1.0 . The difference between the two means is 6.5 times its probable error.

The results of these experiments are consistent. In Experiment 4, where the fish were not confined to any part of the aquaria (they actually remained close to the bottom) and in the second part of Experiment 5 where they were confined to the lower third of the aquaria, the resulting infestation was heavier in the case of those which had been in the dark. This is due simply to the fact that the cercariae are more distributed throughout the upper level of the container in the light. In both cases where the fish were confined in the upper third of the aquaria (Experiments 5, 6), those which were exposed in the light had a significantly higher average number of cysts than those which had been in the dark. Another point clearly demonstrated in Experiment 5 is that both in light and in darkness the fish confined in the lower third of the aquaria became many times more heavily infested than the fish confined in the upper third. Even in the light a large majority of the cercariae remained near the bottom of the container.

RELATIVE INFESTATION OF FINS

It was noted during the experiments on infestation under different conditions of light that the pectoral, pelvic, and caudal fins were more heavily infested, per unit area of surface, than were the dorsal and anal fins. Accordingly, the data have been analyzed and summarized in Table 3. The relative surface areas of the fins, compared to the anal as unity, are: pectorals, 3; caudal, 2; dorsal, 2.5 (spinous dorsal extended), 1.4 (spinous dorsal folded, as usually held); pelvis, 1.7. If the amount of surface exposed to the penetration of the cercariae were the factor which alone determined the degree of infestation, it would be expected that the number of cysts in the different fins would be in proportion to the above numbers. That area is not the only factor is shown by the proportionately heavier infestations of the caudal and pectoral fins.

Comparison has been made only in those experiments where large numbers of cysts were present, experiments 4 and 5 (*c*, *d*). The number of cysts in the anal fin was taken as unity in each instance, and the relative infestation of the other fins compared with it. In all experiments the caudal and pectoral fins contained many more cysts in proportion to their area than did the anal fin. The greatest numbers were present in the fish of Experiment 4 (*b*), where the caudal fin was over three times, and the pectoral fin almost three times as heavily parasitized as expected on the basis of area. The infestation of the pelvic fins and of the dorsal fin (spinous dorsal folded) was on the average only slightly higher than expected.

Observation of the use of the different fins during locomotion or resting was made with the idea that some differences might be found to

explain the high relative infestations of the caudal and pectoral fins. The latter were in almost constant and vigorous motion, while the former moved less actively. The pelvic fins usually remained folded, except when locomotion was arrested, at which time they were employed as "brakes" by being spread perpendicular to the direction of locomotion. The spinous dorsal fin was folded down against the body most of the time, but the soft dorsal and the anal fins were held extended. The data show (Table 3) that the caudal and pectoral fins, which are almost always in motion, are much more heavily infested, in proportion to their areas, than are the other fins.

Additional information on the relative infestation of the fins was obtained from the data of Experiment 3, in which the fish were exposed

TABLE 3.—Relative Degree of Infestation of Fins Compared with Their Relative Total Surface Areas, Referred in Each Case to the Anal Fin as Unity. The Relative Areas of Dorsal Fin with Spinous Dorsal Portion Extended and Folded (as Usually Held) Are Shown. The Figure for the Pelvic Fins Represents the Extended Area

	Pectoral	Caudal	Pelvic	Dorsal	Anal
Relative surface area.....	3	2	1.7	2.5, 1.4	1
Relative degree of infestation					
Exp. 4 (table 2) (a).....	6.5	4.8	2.1	1.7	1
(b).....	8.3	6.5	1.0	2.1	1
Exp. 5 (table 2) (c).....	5.1	4.1	2.5	0.8	1
(d).....	6.5	5.3	1.8	1.4	1
Exp. 3 (table 1) 1st 5 exposures.....	5.0	3.3	2.5	1.2	1

to infestation by cercariae of different ages. The results from the first five exposures (cercariae 2 to 15 hours old), grouped together, show that the infestation of the fins in proportion to their areas is almost exactly the same as in the experiments cited above (Table 3). After this time the total infestation decreased rapidly with the age of the cercariae, and there was a striking change in the relative infestation of the fins (Text-figure 2). The pelvic fins, previously less heavily parasitized than the pectoral and caudal fins, now contained a much larger number of cysts than any of the other fins, despite the fact that the pelvic fins are much smaller and are used less than the caudal and pectorals. The relative increase in the number of cysts in the pelvic fins after the cercariae were more than 15 hours old was probably due to the fact that the cercariae were now on or near the bottom and reached the pelvic fins when the fish rested on the substratum.

DISCUSSION

The general purpose of the experiments described above was to determine the relation of the behavior of *Cercaria floridensis* to the infestation of the fish intermediate host. According to our observations,

the normal swimming behavior of the cercaria was not influenced by the immediate presence of the fish or of tissue fluids from the fish. The cercariae did not show reactions which would indicate an attraction to the host until *after* they became caught by chance contact in the mucus of the fish. Even then some of the cercariae disentangled themselves and swam away. These observations are in accord with those of Faust and Meleney (1924: 54) on the cercaria of *Schistosoma japonicum* but do not agree with those of Faust and Khaw (1927: 67), and Nagano (1925, 1926, quoted by Faust and Khaw), who described the cercariae of *Clonorchis sinensis* as swarming toward the fish in their immediate vicinity.

The most striking reaction in the behavior of *C. floridensis* is the swimming upward of the cercaria in response to shadows. The results of the experiments carried out to throw light on the possible rôle of this reaction in the infestation of the fish do not justify any very definite conclusion. We are of the opinion, however, that the response to shadows does not play a very important part in enabling an individual cercaria to reach the fish which stimulated it. On the other hand, the shadows cast by the fish, or shadows from other agencies such as waves, undoubtedly help to bring the cercariae to the upper levels of water, because the cercariae always swim upward when stimulated. The significantly greater infestation of the fish confined to the upper part of the containers in the light than in the dark is direct evidence in support of this conclusion. If the adult of *Cercaria floridensis* occurs in a fish-eating bird, it would be of advantage to the worm that the cercariae encyst in fish which range near the surface. Hence, it is conceivable that the reactions of the cercariae to shadows are of positive value in the completion of the life cycle of the parasite. However, it is evident that infestation may take place in total absence of light and that under the experimental conditions described above, fish near the bottom of an aquarium become more heavily infested than fish confined near the surface. Apparently chance contact of cercaria and fish is the most important factor involved.

SUMMARY

1. *Cercaria floridensis* is not "chemically" attracted to its fish intermediate host, or by tissue fluids of the fish.

2. Cercariae were able to infest the fish as long as they were active enough to reach them, even up to 36 hours, but infectivity decreased rapidly after 12 hours. The rate of decrease in infectivity was approximately 13% per hour.

3. The pectoral and caudal fins were more heavily parasitized in proportion to area than the other fins.

4. Fish confined in the lower levels of aquaria were more heavily infested when exposed to cercariae in the dark than in the light. Fish confined near the surface were more heavily parasitized in the light due to more nearly uniform distribution of cercariae in such aquaria. The swimming upward of cercariae in response to shadow stimuli is a factor in bringing them toward the surface.

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SPECIFIC CHARACTERS IN THE GENUS TRICHURIS,
WITH A DESCRIPTION OF A NEW SPECIES,
TRICHURIS TENUIS, FROM A CAMEL *

ASA C. CHANDLER

In a recent paper on the specific identity of whipworms from swine, Schwartz (1926) points out that the specific characters in the genus *Trichuris* Roederer 1761 are largely limited to the size of the spicules, the structure of the sheath, and the size of the eggs. Less important and more variable specific characters include the total size of the worms and the ratio of the slender anterior portion of the body to the relatively thick posterior portion. Baylis (1929) relies on the same characters for differentiation of species.

The unsatisfactory nature of these characters, unsupported by other features, is obvious from the fact that whipworms as common as those in man and pigs were almost universally regarded as specifically distinct until 1926, when Schwartz showed that when a sufficient number of specimens were examined, no morphological differences could be demonstrated between the worms obtained from pig, man, or lower primates. Examination of a few specimens would not, however, have made this evident, for the range of variation in the few characters which had to be depended upon is such that apparently valid morphological differences could have been observed, as was actually done by a number of helminthologists in the past. A brief review of these characters shows how unreliable they are, especially when a limited amount of material is available for examination.

Of the characters mentioned the size of the spicules is undoubtedly the most dependable one, and in conjunction with other characters is valuable in differentiation of species. The length in different species varies from about 9 to 11 mm. (8.6 to 10.4 according to my measurements) in *T. vulpis* of dogs and foxes, to about 0.75 mm. in *T. muris* of rats and mice. There is, however, considerable individual variation in the length of the spicules within a single species, and in many species, even in related hosts, there is considerable overlapping, so that this character alone is not always dependable. Thus in *T. trichiura* the measurements vary from 2 to 3.4 mm., while in *T. ovis* they are usually given as from 5 to 6 mm., but two measurements made by the writer were 7 and 7.65 mm. The spicule is always filamentous in form, and varies in diameter in different species, tapering more in some than in others; but the shape of the tip is not always a dependable character, as Schwartz showed in the case of *T. trichiura*.

* Contribution from the Biological Laboratory, Rice Institute, Houston, Texas.

The shape and armature of the spicule sheath is even more variable. In some instances, e. g., *T. globulosa* and *T. cameli* of camels, the presence of a globular or button-like enlargement at the end is given as one of the main differential characters, and Baskakov (1924) describes the sheath of his *T. skrjabini* as being larger proximally than distally, and differentiates this species from both *T. discolor* and *T. cameli* largely on the basis of the shape of the sheath. Schwartz, however, has observed that the shape of the sheath of *T. trichiura* is extremely variable. As he remarks, the spicule sheath in *Trichuris* is a retractile organ and apparently capable of considerable expansion and contraction, since the sheath in retracted position is much narrower than when extruded. It has no permanent shape, as the spicule has, and it is surprising that its shape should ever have been used by helminthologists as a specific character. It is possible that in some species there may be more tendency to the formation of a terminal bulb than in others, but even this is doubtful. Probably the method of killing has much to do with the appearance of the spicule sheath. In his descriptions of *T. alcocki* from *Cervus eldi* and *T. globulosa* of camels, von Linstow went so far as to include the length of exertion of the sheath.

The spiny armature of the sheath seems to have little more value, although the regularity of arrangement of spines, their variation in size in different regions, their distribution, and their form have all been included in descriptions of species of *Trichuris*. According to Schwartz *T. trichiura* may have the spines sparse or dense, evenly distributed or practically absent from certain areas, and either sharply pointed or scale-like. Obviously, therefore, a character which can vary so much within one species is very unreliable in differentiation of species. In some species (e. g., *T. leporis*) the spines are missing entirely. This character seems to be an invariable one, and is of specific value when it is observed.

The size of the eggs is only occasionally of value, for the measurements as given for most species lie between 50 and 60 μ in length and from 25 to 35 μ in width; in *T. ovis* they are larger, varying from 70 to 80 μ in length by 30 to 35 μ broad. Some writers measure the eggs with the opercula, some without them, or give both measurements; if it is not stated whether the opercula are included, one cannot be sure of this. At best the size of the eggs is of doubtful value, since there is so much individual variation within a species.

Total size is of value in the case of certain species, but not in most of them. The length of the thick part of the body, measured from the junction of intestine and esophagus, appears to be more reliable than total length. In *T. minuta* of opossums this part of the body, in males, is less than 10 mm. long, while in *T. ovis* it is 25 to 30 mm. In most species, however, it is from 12 to 15 mm. The maximum diameter of the thick part of the body, especially relative to the length, is

sometimes useful. For example, in *T. trichiura* the length of the posterior part of the body is about 12 mm. with a diameter of about 600μ , while in *T. tenuis*, n.sp., from a camel (described below) it is about the same length, but only 300μ or a little more in diameter; a specimen of *T. ovis* measuring 27.5 mm. had a diameter of 630μ . The diameter of the esophageal portion of the body is fairly constant, if consistently measured in the same place. I made my measurements in the region just anterior to where the body begins to widen out anterior to the end of the esophagus, and where the diameter is fairly constant for several millimeters. There is a very gradual taper towards the head end.

It is doubtful whether, in most cases, the relative length of the slender anterior and thick posterior portions of the body can be depended on. This varies, according to descriptions of various species, from 2:3 to 1:4. In *T. trichiura* the thick part of the body is usually stated to be about 40% of the total length, but in two specimens I measured I found it to be 34% and 35%. In *T. ovis* the ratio is usually said to be 1:4, but in one specimen I measured the thick part occupied 42% of the total length. In a series of male specimens of *T. tenuis* the length of the esophageal portion of the body seemed to bear little relation to the thick part, and varied from 16 to 28 mm. in length in specimens all having a length of the thick part of the body between 11.5 and 12.5 mm., while in a series of females the esophageal portion varied from 23 to 30 mm. without relation to the length of the thick part; the measurements in two extremes were 23 and 10 mm., and 28 and 7.5 mm., respectively, or a ratio of 2.3 to 1 in one case and 3.7 to 1 in the other. From my observations the length and thickness of the posterior portion of the body are the most reliable size measurements.

It is obvious, from what has been said, that the characters hitherto used for the differentiation of species of *Trichuris* are very unsatisfactory, and while they may be adequate when a large amount of material is available, so that differences due to individual variation can be excluded, they are not adequate when only a few specimens are available. In an effort to find more and better-defined characters for the differentiation of species, I have examined the internal anatomy of male specimens of *Trichuris* from eight different hosts, representing six different species, and have found a number of characters which seem to be highly reliable and easily determinable, and which should, therefore, be included in descriptions of species of this genus. Most of the characters concern the male reproductive organs.

In the male *Trichuris* the testis begins in the region of the cloacal tube, behind the junction of the intestine and reproductive tube. It runs forward as either a straight or more or less coiled tube to the level of the esophago-intestinal junction and then turns back as the sperm duct, or vas deferens, which usually is straight but may have

a few kinks in it. Somewhere in its length it has a constriction behind which it widens again to form the straight ejaculatory duct, with narrower lumen, which later joins with the intestine to form the cloacal tube. The latter is muscular and has, somewhere near the middle of its length, a forward-extending diverticulum in which the proximal portion of the spicule usually lies. This diverticulum may be referred to as the spicular tube.

The extent to which the details of these organs vary in different species of *Trichuris* is truly remarkable, yet there is strikingly little variation within a species. The cloacal tube and its diverticulum, the spicular tube, present a number of diagnostic characteristics in the six species which have been examined. In the first place, the cloaca most commonly lies entirely behind the junction of intestine and sperm duct, but in *T. tenuis* it is recurved at its origin and joins with the spicular tube far anterior. In the other species it varies in length from less than 2.5 mm. in *T. minuta* to over 9 mm. in *vulpis*, and occupies, in different species, from one-fourth to one-half the length of the thick part of the body. In one species, *leporis*, the spicule lies in the cloaca, its proximal end just behind the junction of intestine and sperm duct, and the spicular tube is empty. Only two specimens were available for study, but this unusual condition existed in both of them. In consequence of the partial retraction of the spicule, the cloaca in one specimen was thrown into loops, a condition never seen in other species.

The two portions of the sperm duct, the posterior of which has been designated the ejaculatory duct and the anterior the vas deferens, also present striking differences. In some species (*trichiura*, *vulpis*, and *ovis*) the ejaculatory duct is markedly shorter than the vas deferens, while in others (*tenuis*, *leporis* and *minuta*) the opposite is true. The length of the ejaculatory duct is fairly constant in each species, whereas the vas deferens tends to vary with the length of the thick portion of the worm. In three specimens of *T. trichiura*, for example, the lengths are as follows:

Length of Thick Portion	Cloacal Tube	Ejac. Duct.	Vas Deferens
11.5	3.3	2.9	5.4
12.6	3.6	3.2	5.4
14.8	3.4	3.4	8

In *trichiura* the two parts are connected by a narrow twisted duct, while in all of the others there is merely a muscular constriction. In *vulpis* the anterior part of the tube is thrown into a number of kinky folds, while in other species it is straight; this species also differs in having both parts of the sperm duct less than half the diameter of the body.

The testis shows marked differences in the degree to which it is convoluted. In *minuta* and *vulpis* it is straight; in *trichiura*, *leporis*

and *tenuis* it is thrown into kinky folds so that it presents the appearance of a succession of squarish compartments; and in *ovis* the posterior part is straight but the anterior part is thrown into conspicuous convolutions, which are looser in the middle region of the body than they are anteriorly.

The intestine varies especially in its diameter. In *ovis* and *tenuis* it is very narrow, in *leporis* slightly less so, in *trichiura* and *minuta* still less, and in *vulpis* it is relatively very broad, over half the diameter of the body and broader than the sperm duct.

Examination of large numbers of specimens of *T. tenuis* from a camel, of *T. vulpis* from dogs, and several specimens of *T. trichiura* from man, pig and Hanuman monkey, *Semnopithecus entellus*, and at least two specimens of each of the others, has indicated that these characters are constant within the species and can advantageously be used as specific characters. Practically all of the characters are easily seen by clearing in phenol, after which the specimens can be preserved in alkalinized 70% alcohol, after one or two preliminary washings in this reagent. In some instances the course of the tubes is more easily seen after staining by adding a drop of saturated alcoholic solution of basic fuchsin to a few cc. of the liquefied phenol, and then washing briefly in the clear phenol. Only in the case of the recurved, forward-passing loop of the cloaca of *T. tenuis* was any difficulty encountered in tracing the tubes.

Since the characters named above add so much to the specific descriptions of the various species of *Trichuris* the outstanding characters of the males of those species which I have had an opportunity to examine are re-described below, together with the description of both sexes of a new species which was found in enormous numbers in the intestine of a camel that died in the Houston Zoological Garden.

Trichuris trichiura. Male: thick portion of body 11.5 to 14.5 mm. long, the esophageal portion about one and one-half to two times this length. Diameter of esophageal portion of body about 165 to 180 μ , of thick portion 550 to 650 μ . Spicules about 2.5 to 2.7 mm. long, about 56 μ broad just behind the slight flare at the proximal end, and about 29 μ broad near the tip. The spicule sheath is large and spiny, and usually presents an enlargement at its tip when exerted. Cloacal tube very broad, about 3.3 to 3.6 mm. long, roughly one-fourth the length of the thick part of the body. Spicular tube short, arising posterior to middle of length of cloacal tube, and ending well posterior to the origin of the cloacal tube. Ejaculatory duct coarse, over half the diameter of the body, not highly muscular, and about 2.9 to 3.4 mm. long, and hardly more than half as long, sometimes much less than half as long, as the vas deferens, with which it is connected by a short narrow tube about 0.5 mm. in length. Vas deferens 5 to 8 mm. long, thick, without convolutions. Testis ends near the origin of the cloaca,

and is thrown into kinky convolutions, giving the appearance of a series of squarish compartments, for its entire length. Intestine moderately broad.

T. vulpis. Male: Thick portion of body about 17 to 18.5 mm. long, the esophageal portion a little over twice this length. Diameter of esophageal portion about 145μ , of the thick portion about 500μ . Spicule 8.6 to 11 mm. long, about 46μ broad proximally and 21μ distally. The spicule sheath usually fits the spicule rather closely, and is covered with dense spines basally but is smooth distally. Cloacal tube exceptionally long, about 9 mm., and approximately half the length of the thick portion of the body. Spicular tube arises somewhat anterior to the middle of the length of the cloaca. Ejaculatory duct only a little over 2 mm. long, less than half the length of the vas deferens, with which it is connected by a muscular constriction. Both the ejaculatory duct and the vas deferens are narrower than the exceptionally broad intestine. The vas deferens has a few kinky convolutions in its anterior portion. The testis is perfectly straight, without convolutions, and ends far behind the junction of the spicular tube with the cloacal tube.

T. ovis. Male: Thick portion of body 25 to 28 mm. long, the esophageal portion only 1.4 times as long in one specimen measured, although the anterior portion is commonly stated to occupy three-fourths of the entire length. Diameter of esophageal portion about 170μ , of the thick portion about 630μ . Spicule 7 and 7.65 mm. long in two specimens measured, although usually stated to be 5 to 6 mm. "or more"; a very marked flare at the proximal end, the flare measuring 140μ across. Just behind the flare the spicule has a diameter of about 65μ , near the tapering distal end about 30μ . Spicule sheath spiny, usually enlarged at tip when exerted. Cloacal tube about 6 mm. long, less than one-fourth length of thick part of body. Spicular tube diverges posterior to middle of length of cloacal tube. Ejaculatory duct about 7.5 mm. long, but only about two-thirds as long as the vas deferens, with which it is connected by an inconspicuous constriction. Testis ends shortly behind the origin of the cloacal tube; its posterior portion is straight while in the middle of the body it is thrown into conspicuous loops, and further forward into close convolutions. Intestine very narrow, less than half the width of the reproductive tubes.

T. minuta. Male: Thick portion of body 9.8 mm. long; in the single specimen available esophageal portion incomplete, but 20 mm. present, therefore at least over twice as long as thick part. Diameter of esophageal portion about 108μ , of thick portion 310μ . Spicule 1.25 mm. long, about 16μ broad proximally. Spicule sheath spiny, retracted in specimen examined. Cloacal tube 2.36 mm. long, slightly less than one-fourth length of thick part of body. Spicular tube

diverges from cloacal tube posterior to middle of its length, and falls far short of reaching the origin of the cloaca. Ejaculatory duct 4.3 mm. long, nearly twice the length of the cloaca, and longer than the vas deferens, with a length of about 3.2 mm. The vas deferens and ejaculatory duct are jointed by a muscular constriction. Testis straight, with no convolutions, ending in the region of the spicular tube.

T. leporis. Male: Thick part of body 15 and 16.5 mm. long, respectively, in two specimens which I measured; the esophageal portions were incomplete. Hall (1916) gives the total length as 29 to 32 mm., the ratio of esophageal to thick portions being 3:2. Diameter of esophageal portion about 150μ ; of the thick portion 550μ (Hall gives the diameter as 430μ). Spicule 6.7 and 7.8 mm. long, respectively, in my specimens. Hall gives 1.87 to 7 mm., but remarks that the amount of variation in the reported spicule lengths suggests either error in measurement or confusion of species. Spicule sheath without spines, narrow and diaphanous, varying in appearance according to degree of exertion and contraction, but usually have constrictions which give it a beaded appearance. Cloacal tube very narrow, 5.3 and 6.4 mm. long in two specimens, about 35% of length of thick part of body. Spicular sheath present, ending well in front of origin of cloaca, but apparently not functional in the two specimens examined, for in both the spicule lies *not* in the spicular tube but in the cloacal tube, its proximal end lying just behind the junction of intestine and ejaculatory duct. In one specimen, in which the spicule is not exerted as far as in the other, the cloacal tube is thrown into "S"- and "8"-shaped loops, a condition never observed in other species, and apparently due to the inability of the spicule and its sheath to pass forward beyond the junction of intestine and cloaca, which are presumably provided with sphincters. Whether this unusual condition with respect to the situation of the retracted spicule is a constant feature of this species it is impossible to say without examination of a larger series of specimens. Ejaculatory duct very long (7 and 7.6 mm.), nearly half the length of thick part of body, and over twice as long as the vas deferens, which measures 3 and 3.5 mm. in my specimens. These parts of the reproductive tube are joined by an inconspicuous muscular constriction. Testis convoluted in such a way as to give the appearance of a series of squarish compartments, as in *trichiura*, and ending near the middle of the length of the cloacal tube. Intestine of moderate diameter.

T. tenuis, n. sp. Male: thick part of body about 11 to 13 mm. long, and very slender, having a diameter of from 310 to 360μ . Esophageal part of body of very variable length, from 16 to 28 mm. long, without apparent relation to the length of the thick part. In most specimens the respective length of the two parts of the body are about

12 and 21 mm. Diameter of esophageal portion about 145μ . Spicule 4 to 5.5 mm. long, and extremely slender; proximal diameter about 20μ , tapering to 5μ near the tip. In every one of fifty or more specimens examined the spicule was retracted, the tip lying far anterior to the origin of the cloaca. Spicule sheath narrow, without spines. The long narrow cloaca does not pass directly posteriorly to the end of the body as in other species, but turns forward and joins the spicular tube 3 to 5 mm. anterior to its origin. The forward-passing tube and its junction with the spicular tube is very difficult to see in most specimens. The combined length of the cloacal tube from its origin to its junction with the spicular tube, and then back to its termination at the end of the body, is over 10 mm., nearly the length of the body. The origin of the cloacal tube, however, lies little over 2 mm. from the posterior end. The ejaculatory duct, which is much more muscular than in any other species examined, is about 6 mm. long, much longer than the vas deferens, which is 3.2 to 4.5 mm. long. The junction between these two parts of the reproductive tube is in the form of a muscular constriction. The testis, which ends behind the origin of the cloacal tube, is moderately convoluted for its entire length. The intestine is narrow, only about half the diameter of the reproductive tube.

Female: Thick part of body 7.5 to 11 mm. long, with a diameter of about 300 to 320μ . Esophageal part of body 25 to 35 mm. long and 120 to 130μ in diameter, its length bearing no ratio to the length of the thick part, but varying from less than two and one-half to nearly four times as long. Vulva very slightly posterior to junction of esophagus and intestine. Ovary begins about 200μ from posterior end, and is connected with the posterior part of the body by a ligament-like structure; it passes forward as a much convoluted tube about 120μ in diameter, to a point 1 mm. or less behind the vulva and then turns back as a narrow tube, 13 to 14μ in diameter, much convoluted anteriorly but becoming nearly straight posteriorly. This tube turns forward again about 1 mm. from the posterior end and rapidly widens out to form the uterus, which is about 250μ in diameter and is filled with eggs. About 2 mm. behind the vulva the uterus abruptly narrows to a smaller, very muscular, and convoluted ovejector which leads to the vulva. The intestine is straight, and is abruptly rounded where it joins the rectum about 100μ from the posterior end. Eggs measure 54 to 60μ long, including the opercula, and about 46 to 50μ without it, and have a breadth of from 28 to 30μ .

Host: *Camelus dromedarius*.

Locality: Houston Zoological Garden, Houston, Tex.

Type specimens deposited in U. S. National Museum.

This worm was present in enormous numbers, certainly exceeding 20,000, and probably exceeding 50,000, in the intestine of a camel

EXPLANATION OF PLATE XIII

Males of *Trichuris ovis*, *T. tenuis* and *T. minuta*.

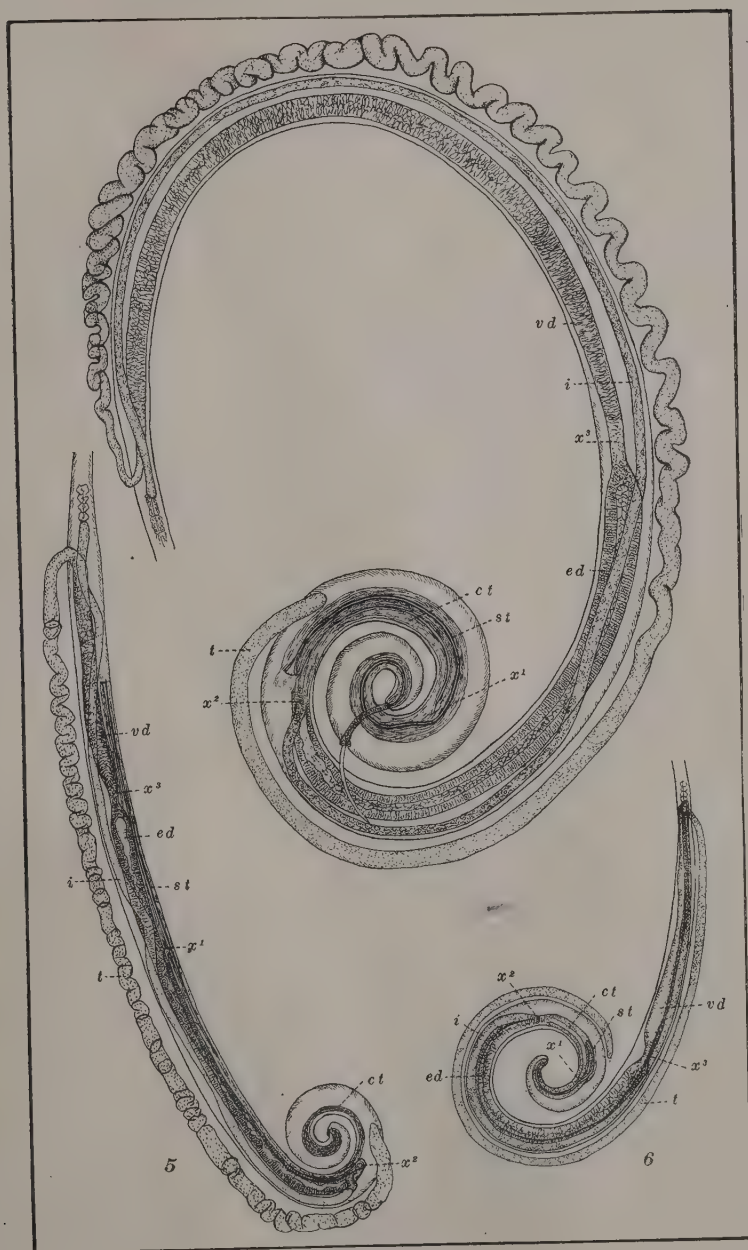
All figures $\times 12.5$.

Fig. 5.—*Trichuris ovis*.

Fig. 6.—*Trichuris tenuis*.

Fig. 7.—*Trichuris minuta*.

Abbreviations: *ct*, cloacal tube; *ed*, ejaculatory duct; *i*, intestine; *st*, spicular tube; *t*, testis; *vd*, vas deferens; x^1 , junction of cloacal tube and spicular tube; x^2 , junction of intestine and ejaculatory duct to form cloacal tube; x^3 , junction between ejaculatory duct and vas deferens.



THE LIFE HISTORY OF TWO NORTH AMERICAN FROG LUNG FLUKES*

WENDELL KRULL

The life history of *Pneumonoeces medioplexus* Stafford and *P. parviplexus* Irwin have been worked out experimentally in the laboratory using *Rana pipiens* Schreber for the definitive host of the former and *R. clamitans* Latr. for the latter.

P. medioplexus lives as an adult parasite in the lungs of the leopard frog, *Rana pipiens*, and has larval stages in a snail, *Planorbula armigera* (Say), and certain dragonflies of the genus *Sympetrum*. Common toads, including some only 13 mm. long, have been infected experimentally and the parasites arrived at maturity in them, but naturally infected toads have not been taken by the author, although Stafford (1902) reported this fluke from toads in nature. *Rana clamitans* has also been reported as a host of *P. medioplexus*, but since this species could not be infected experimentally it has not been included in the list of hosts.

The parasites produce eggs in great numbers which pass from the lungs through the glottis into the mouth cavity. They are swallowed, pass through the digestive tract and are voided with the feces. The eggs containing mature miracidia are deposited in this way in the shallow water along the margins of ponds and lakes where snails are usually abundant. The miracidia remain alive within the eggs for weeks without hatching, and can only be induced to hatch by feeding them to snails. It is therefore concluded that it is necessary for the snails to eat the eggs in order to become infected, although experimental infections have not yet been tried. The eggs hatch during passage through the digestive tract of other snails than the regular host snail.

The miracidia are small (25μ in length), covered with a dense coating of long cilia, and move relatively slowly. Mother sporocysts have not yet been seen. The elongated, sausage-shaped daughter sporocysts are located in the digestive gland of the snail, *Planorbula armigera* (Say), where they give rise to comparatively few cercariae which make their escape from the snail in greatest numbers in the morning.

The cercariae spend most of their time swimming aimlessly in the water by lashing their tails, but at times they creep by means of their suckers. When creeping the tail is contracted, except for a periodic elongation during which there is a short period of lashing, especially

* Contribution from the Zoological Laboratory and the Biological Station of the University of Michigan.

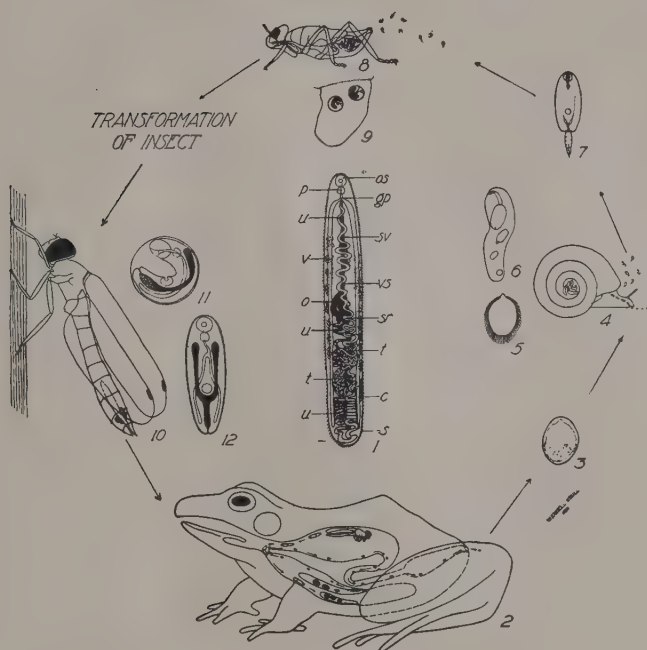
noticeable when they are under a cover glass. Swimming keeps them suspended in the water, a function which is of great importance in bringing them into association with dragonfly nymphs, the next intermediate host.

Dragonfly nymphs (larvae) respire by means of a unique respiratory organ which develops from a portion of the rectum and is called a branchial basket. This organ is a large barrel-like chamber from the wall of which longitudinal sets of leaf-like gills or lamellae project inwardly. Since the entire organ is lined with a chitinous cuticula each lamella is covered by a thin layer of it. Respiratory movements cause water to pass in and out of the respiratory organ through the anal opening. These respiratory movements, which are usually more or less rhythmical, create currents of water around the nymph.

Cercariae swimming in the vicinity of the nymph are caught by these respiratory currents and are swept into the chamber of the branchial basket through the anal opening. Doubtless, cercariae are thus swept into the branchial baskets of many kinds of dragonfly nymphs, while many cercariae never enter a nymph. The latter cercariae usually die within twenty-four hours and those which enter other nymphs than the ones belonging to the genus *Sympetrum* also die. Those which enter the respiratory organ of *Sympetrum* nymphs penetrate through the chitin into the tissues of the lamellae. These metacercariae encyst shortly within thin, structureless, transparent, pliable cysts where they ordinarily attain maximum size within fourteen to twenty days. However, they are infective when much smaller; indeed they are known to be infective after a six days' sojourn in the nymph, and may be infective even earlier.

The encysted metacercariae remain in the lamellae until the nymph transforms into an adult dragonfly. During transformation the nymphal respiratory organ breaks down and disappears except for a small vestige which constitutes a short region in the posterior end of the digestive tract of the adult insect in which these encysted metacercariae are crowded together. Hundreds may be found in a single insect. They live here in a more or less inactive condition until the host dies in the fall of the year or until such a parasitized dragonfly is eaten by a leopard frog or a common toad. In the stomach of either animal the insect is sufficiently digested to free the metacercariae. These are stimulated to activity by the digestive fluid and creep up the esophagus in measuring-worm fashion. From the esophagus they pass through the glottis into the lungs, where they reach maturity, under optimum conditions, in twenty-eight or thirty days from the time they enter the frog. The flukes grow considerably after attaining maturity.

The cercariae belong to the ornate group of xiphidiocercariae of which only a few have been described. They are among the smallest of the stylet cercariae, measuring while alive with the tail contracted



EXPLANATION OF TEXT-FIGURE

1. *Pneumonoeces medioplexus* from the lungs of the leopard frog, *Rana pipiens*; os, oral sucker; p, pharynx; gp, genital pore; u, uterus full of eggs; sv, seminal vesicle; v, vitellaria; vs, ventral sucker; o, ovary; sr, seminal receptacle; t, testis; c, cecum; s, spines. 2. Leopard frog, showing the escape of the metacercariae from the dragonfly in the stomach and their migration to the lungs, a developing form in the lung, an adult parasite depositing eggs, and the course taken by the eggs to the exterior. 3. Egg containing miracidium. 4. *Planorbula armigera* (Say), eating eggs, also showing sporocysts in the digestive gland, and cercariae escaping from the snail. 5. Miracidium. 6. Sporocyst with cercariae in various stages of development. 7. Cercaria showing body, tail, stylet, oral sucker, pharynx, ventral sucker, and excretory bladder. 8. Nymph of the dragonfly, *Sympetrum obtrusum* Hagen, showing the swimming cercariae being taken into the respiratory organ of the nymph, and several encysted metacercariae in the lamellae. 9. Lamella from the respiratory organ of the nymph containing two encysted metacercariae. 10. Adult dragonfly with encysted metacercariae within the vestige of the nymphal respiratory organ. 11. Encysted metacercaria. 12. Metacercaria removed from cyst showing oral sucker, pharynx, esophagus, intestinal ceca, ventral sucker, excretory bladder, and spines.

150 μ long. One-third or one-fourth of the length of the cercaria consists of tail, depending upon the degree of contraction. The stylet is about 17.5 μ long, has a pair of low, rounded, dorso-lateral protuberances and a ventral swollen area near the pointed anterior end; posterior to this the shaft is cylindrical. There is a considerable number of stylet glands (penetration glands) located near the ventral sucker, but their precise number has not been determined owing to the opacity of the cercariae. The oral sucker measures 39 μ , the ventral sucker 24 μ , while the pharynx is a little smaller. The ventral sucker is located about two-thirds of the distance from the anterior end of the body. When contracted the margin of the tail is usually deeply folded. A rather broad dorso-ventral fin-fold passes around the distal end of the tail and extends anteriorly about to the middle on the ventral side and half as far on the dorsal side. When completely relaxed the tail is as long as the body.

Full grown metacercariae measure 600 by 250 μ . The cuticula of both dorsal and ventral surfaces is beset with fine spines. In diameter the oral sucker measures 75 μ , the ventral 60 μ . There is a short pre-pharynx, a well developed pharynx, 50 μ in length, followed by a somewhat longer esophagus, and a pair of ceca reaching nearly to the posterior end of the body. In the metacercaria the most conspicuous structure is the large "Y" shaped excretory vesicle, whose cornua, two or three times as long as the stem, extend anteriorly to the posterior end of the pharynx. Refractile granules fill the entire bladder.

The lengths and widths given above are based on measurements of living worms while inactive and not under pressure. Dimensions of suckers and pharynx are based on measurements of living material under some pressure just before they began to disintegrate. Results obtained in this way were reasonably constant and the ratios of the measurements of the structures thus obtained agree with corresponding ratios of measurements obtained on preserved material.

Pneumonoeces parvipleus Irwin lives as an adult parasite in the lungs of the green frog, *Rana clamitans* Latr. and has larval stages in a snail, *Gyraulus parvus* (Say), and dragonflies of the genus *Sympetrum*. The structural characteristics of the developmental stages of these two species of lung fluke resemble each other so much that it has been practically impossible to differentiate them, consequently the larval stages of *P. parvipleus* need not be described here.

The cercariae of this form escape from the snail in the afternoon rather than in the morning. The cercariae enter the nymphs and the frogs obtain the metacercariae in the same way as in the preceding form. The flukes mature in the final host in the same number of days as in the previous form.

In order to secure frogs free from parasites, tadpoles were collected from two acid lakes and allowed to metamorphose in the laboratory.

These acid lakes are free from snails as shown by observations of various investigators during the last few years. Jewell and Brown (1924, 1926) and Brown and Jewell (1929) have reported limnological studies of these lakes extending over the period 1923-1926. Dr. P. S. Welch, University of Michigan, has informed me that he and his students have made extensive observations on one of these lakes over a period of six years. The absence of snails from these lakes permits the assumption that tadpoles living in the lakes would be free from trematodes. However, the taking of tadpoles from acid lakes appears to have been an unnecessary precaution since later studies showed that tadpoles from infested as well as uninfested habitats do not carry lung flukes. Moreover, I was unable to infect them experimentally by feeding them cysts containing metacercariae.

As host for the metacercariae of both life histories the dragonfly, *Sympetrum obtrusum* Hagen, was used, although in nature they have been found in *S. rubicundulum* Say and an unidentified species. It is possible that they may occur in any species of the genus within the range of the parasite. Parasite-free dragonflies, *S. obtrusum*, were reared in the laboratory from eggs and were fed on food also raised in the laboratory by methods related elsewhere (Krull, 1929). They had no contact with snails at any time. The dragonfly nymphs were infected during the later instars by placing them with a certain number of cercariae in a small amount of water at room temperature. My collection and rearing data show, however, that nymphs in nature may become infected as early as the second instar.

Tissue containing cysts from the experimentally infected dragonflies (nymphs or teneral) was fed to frogs by placing it in the mouth by means of a dropper or a pair of forceps. Metacercariae, kept in normal saline solution until freed from their cysts, were found to be equally as infective as those in cysts or in cysts in the tissues of the dragonfly. The frogs were placed in canvas pens covered with netting to prevent their securing a natural infestation. Controls were kept in the same way in the same general location but these pens were not covered. The control frogs did not become infected. This result is in accord with the fact that but few *Sympetrum* were observed near the pens during the entire summer, and the three collected and examined contained no metacercariae. The nearest breeding place for *Sympetrum* was nearly two miles from the frog pens.

Frogs of both species free from lung flukes were fed naturally infected *Sympetrum* adults and these parasites came to maturity in the lungs, showing that *Sympetrum* is the natural host for both these forms.

For verification of species the author gratefully acknowledges the privilege of examining the type specimen of *P. parviplexus* Irwin loaned by Dr. W. A. Riley, University of Minnesota, and mounted specimens of *P. medioplexus* Stafford loaned by Dr. W. W. Cort, Johns Hopkins

University, on which his re-description of the species was based. The author is greatly indebted to Dr. George R. La Rue, University of Michigan, for aid and suggestions in the preparation of this paper.

A more detailed account of the life history of the two forms along with the experimental work involved is being prepared.

The life cycle of *P. medioplexus* is diagrammatically illustrated in the text figure.

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TWO NEW TREMATODES FROM THE BILIARY DUCTS OF BIRDS FROM ARMENIA *

K. I. SKRJABIN AND A. N. UDINZEW

During the work of the tenth Helminthological Expedition of the Union in Armenia in the autumn of 1923, we happened to detect two new Trematodes, representatives of the family Dicrocoeliidae: *Oswaldoia alagesi* nov. sp. from the biliary ducts of the liver of *Pica pica* and *Lyperosomum papabejani* n. sp., from the biliary ducts of a mountain partridge, *Caccabis chukar*.

The aim of this article is to give a description of the new species and to present a key for the determination of all known species of the genus *Oswaldoia* Travassos 1919 and *Lyperosomum* Looss 1899.

Oswaldoia alagesi nov. sp.

[Fig. 1]

Host: *Pica pica* N 4413 and N 4418.

Location: Biliary bladder.

Occurrence: November 14, 1923, in the district of Erivan (Armenia).

Frequency: In two only among specimens of *Pica pica* dissected by the expedition.

The body, of a spindle like form, has a length of 6.5 to 7 mm. and a maximum breadth of 0.9 to 0.93 mm. at the level of the ventral sucker. The oral sucker, 0.2 by 0.275 mm. Pharynx, 0.16 mm. in length with a breadth of 0.1 mm. The center of the ventral sucker is situated at a distance of 1.45 mm. from the cephalic end. The ventral sucker has a diameter of 0.78 mm. The testes are oval in form, 0.24 by 0.27 and 0.29 by 0.27 mm. in size; they are situated obliquely to one another, whereby the anterior testicle is separated from the posterior margin of the ventral sucker only by a small loop of the uterus; in the same way is the posterior testis separated from the anterior by a row of loops of the uterus. The round ovary, 0.26 to 0.29 mm. in diameter, lies to the left from the median line; the vitellaria, 2.0 to 2.1 mm., begin directly behind the posterior testes and terminate nearly on the limit between the middle and posterior thirds of the body's length. The length of the body from the posterior end to the posterior limit of the vitellaria is nearly equal to the length of the latter. The uterus covers nearly the whole portion of the body from the posterior vitellaria to

* From the material of the Tenth Helminthological Expedition of the Union in 1923.

the caudal end, leaving only space for the ovary and not passing the lateral limit of the vitellaria.

The eggs have a length of 46 to 47 μ and a breadth of 29 to 30 μ .

THE SPECIES OF THE GENUS OSWALDOIA TRAVASSOS 1919

Up to the present only 7 species of the genus have been described, so that the new species is the eighth. *Oswaldoia skrjabini* (Solow. 1913) is parasitic in the biliary duct of Corvidae, from which our new species is sharply distinguished by the general appearance, the situation of the vitellaria and the size of the eggs. From the biliary ducts of the liver of *Pica pica* was described *Platynosomum panduriforme* Raill. 1900.

KEY TO KNOWN SPECIES

A. Ovary situated at considerable distance from testes.

I. Body length not beyond 3 mm.; parasites of *Tanagra fulmarum*
.....*O. marquesi* (Trav. 1922)

II. Body length does not exceed 6 mm.

a. Eggs large, 46 to 47 μ in length; parasite of *Pica pica*
.....*O. alagesi* Skrj. and Udinz. 1930

b. Eggs less than 35 μ .

1. Length of eggs, 28 to 34 μ . Parasite of *Crex cres* (L.).
.....*O. pawlowsky* Strom 1928

2. Length of eggs, 25 to 28 μ . Parasite of *Crex alector*.
.....*O. direptum* (Nicoll 1914)

B. Ovary situated near vitellaria.

a. Uterus forms dense coil anterior to ventral sucker.
.....*O. mosquensis* Skrj. and Issait. 1927

b. Uterus does not form coil anterior to ventral sucker.

1. Vitellaria short, not surpassing one-fourth of body length.
.....*O. collurionis* Skrj. and Issait. 1927

2. Vitellaria long, not less than one-third of body length.

3. Anterior limit of vitellaria at posterior margin of posterior testis.....*O. oswaldoi* Travassos 1919
Anterior limit of vitellaria at anterior margin of anterior testes.....*O. skrjabini* (Solowiew 1913)

Lyperosomum papabejani nov. sp.

[Fig. 2]

Host: *Caccabis chukar* N 4313 and 4314.

Location: Biliary bladder and biliary ducts of the liver.

Occurrence: October 22, 1923, in the district of Erivan (Armenia).

Frequency: From 30 specimens of *Caccabis chukar*, in two only.

The body of the parasite has an elongated form, 6.561 mm. in length with a maximum breadth of 0.5854 to 0.6118 mm. The oral sucker is situated subterminally; its diameter is 0.354 by 0.3458 mm. Pharynx is 0.0992 mm. in length and 0.0896 mm. in breadth; from it originates a rather long esophagus (0.1920 mm.). Some distance before the bifurcation is situated the genital aperture. The ventral sucker reaches in diameter 0.2730 by 0.2912 mm.

The testes, of a rather irregularly elongated lobular form, are situated obliquely, at a distance of 36 to 40 μ from one another in the long axis of the parasite's body; anterior testis is smaller than the posterior, the former measuring 0.5824 by 0.2730 mm., the latter, 0.7280 by 0.3822 mm.

Directly behind the posterior testis, near the side of the body, is situated the pyriform ovary. Its diameter is 0.1920 to 0.1456 by 0.2364 to 0.1244 mm. Caudally to the ovary lies an oval receptaculum seminis 0.1120 by 0.0672 mm. to 0.0960 by 0.0672 mm. The vitellaria have an extent of 0.1456 to 0.1647 mm. and are situated above the median portion of the uterus. The left vitellaria take origin at the level of the ovary, the right posterior to the receptaculum seminis. The uterus fills the whole posterior portion of the body, leaving a space only for the vitellaria on the margins, but not filling up the end of the caudal part, where the excretory vesicle is seen. The uterus encircles the posterior testis, winds along the anterior testis from the right and passes to the genital aperture, without forming any further loops. The eggs are oval and measure 16 by 28.8 μ in size.

The bottom of the cirrus sac passes slightly posterior to the margin of the ventral sucker.

This species we name in honor of the worker of Armenia, director of the Agricultural Laboratory, Professor Papa Bejan Kalantarian, who gave us noteworthy help during our sojourn in Armenia.

There has been already described one representative of *Lyperosomum*, from *Caccabis chukar*, collected within the limits of Turkestan, as well as *Lyperosomum corrigia* Brn. 1901. Our species is the second representative of this genus from the mountain partridge, differing sharply from *L. corrigia* by a number of features as is clearly seen from the key.

HISTORICAL SURVEY OF SPECIES OF LYPEROSOMUM LOOSS 1899

The genus *Lyperosomum* Looss, 1899, contains at the present time 30 species and 5 subspecies, 15 species and 5 subspecies of which have been discovered in the territory of U. S. S. R. Originally Looss (1899) included in the genus *Lyperosomum* which he founded *L. porrectum* (Braun 1899), *L. longicauda* (Rud. 1809), *L. strongylosum* Looss

1899, *L. plesiostomum* (Linstow 1883). Later Looss (1907) added to the genus *L. lobatum* (Raill. 1900), *L. alssoni* (Raill. 1900) and *L. clathratum* (Deslongchamps 1824). However, with the formation of the genus *Platynosomum* in 1907, he assigned *clathratum* to this later genus.* Braun (1901) added to genus *Lyperosomum* *L. corrigia*, *L. salcbrasum* and *L. rudectum*. Von Linstow described in 1906 *L. squamatum*, but K. I. Skrjabin proved in 1913 that this species ought to be excluded from that genus. Skrjabin (1913) added the new species *L. filiforme*. Nicoll (1914) described *L. scitulum* and *L. direptum*; however, *direptum* was later removed by Travassos (1919) to the genus *Oswaldoia* Trav., (1919). Johnston (1917) described as species of this genus *L. parvum*, *L. megastomum* and *L. harrisoni*. Travassos (1917) added *L. obliquum*, *L. transversum*, *L. rarum*, *L. lari* and *L. sinuosum*.

In 1919, Isaitschikoff described *L. donicum*; he showed also that one species of the genus *Dicrocoelium* Duj., 1845, is a representative of *Hyperosomum*, namely, *L. attenuatum*. Layman (1922) added *L. magnitestium*, *L. vanellicola*, *L. transverso-genitalis* and described, besides, for the last species a subspecies *L. transverso-genitalis turkes-tanicum*. He added as well in 1923 to the representatives of this genus *L. fringillae*, and in 1926 the subspecies *L. transversogenitalis donicum* and the species: *L. lanicola*, *L. asowi*, *L. loossi* and *L. alaudae*. Bhalerao (1926) added the species *L. kokea*. Semenow (1927) and described the subspecies: *L. transversogenitalis sylvestris*, *L. filiforme biologica*, *L. labatum glandarii*. Baylis (1927) demonstrated that *Distoma vitta* (Dujardin, 1845) should be *L. vitta* (Dujardin, 1845). And finally, in the present work is described the last discovered species of the genus *Lyperosomum*—*L. papabejani* Skrjabin and Udinzew 1930.

In conclusion is added a key for all species and subspecies of the genus *Lyperosomum*, described up to the present, excluding 3 species of Johnston, described in publications which are not obtainable in the libraries of U. S. S. R.

KEY TO SPECIES OF LYPEROSOMUM LOOSS 1899

(The key was prepared by Layman in 1926 and supplemented and changed by the authors in 1930.)

- 1 (4, 13) Vitellaria begin anterior to ovary..... 2
- 2 (3) Vitellaria begin at anterior testes.....*L. longicauda* (Rudolphi) 1809
Length of body 8 to 11 mm. Host, *Corvus corone*, *Corvus cornix*.
- 3 (2) Vitellaria begin at posterior testes.....*L. lari* Travassos 1917
Length of body 3 to 3.5 mm. Host, *Larus dominicanus*.
- 4 (1, 13) Vitellaria begin at level of ovary..... 5

* According to Travassos (1917) *P. clathratum* was included in the genus *Platynosomum* Looss, 1907, not by Looss, but by Travassos.

- 5 (6) Ovary lobed.....*L. plesiostomum* (von Linstow) 1883
Length of body 12 mm. Host, *Perdix graeca*.
- 6 (5) Ovary entire 7
- 7 (10) Vitellaria asymetric 8
- 8 (9) Length of body 10 to 13 mm., testes elliptic.....*L. corrigia* Braun 1901
Parasite of pancreas and intestine. Eggs 32 by 22.8 μ . Host, *Tetrao tetrix* and *Caccabis chukar*.
- 9 (8) Length of body 6.5 mm. Testes irregular.....
.....*L. papabejani* Skrjabin and Udinzew 1930
Parasite of liver. Eggs 28.8 by 16 μ . Host, *Caccabis chukar*.
- 10 (7) Vitellaria symmetric 11
- 11 (12) Length of body 3.55 mm. Ovary round....*L. obliquum* Travassos 1917
Host, *Turdus amauro-chalinus*.
- 12 (11) Length of body 6.8 to 7.2 mm. Ovary transversely oval.....
.....*L. scitulum* Nicoll 1914
Host, *Lorius domicella*.
- 13 (1, 4) Vitellaria begin posterior to the ovary..... 14
- 14 (20) Ovary larger than testes..... 15
- 15 (16, 17, 18, 19) All genital glands transversely oval.....
.....*L. fringillae* Layman 1923
Eggs 19.6 to 24 by 96 μ . Length of body 2.03 to 2.056 mm. Host, *Fringilla coelebs*.
- 16 (15, 17, 18, 19) Ovary longitudinally oval; testes transversely oval....
.....*L. strigosum* Looss 1899
Eggs 42 by 25 μ . Length of body 3.5 mm. Host, *Merops apiastor*.
- 17 (15, 16, 18, 19) Ovary nearly round; testes elongated, longitudinally
oval.....*L. filiforme* Skrjabin 1913
Eggs 50 to 49.3 by 23.2 μ . Length of body 4.25 to 6.8 mm.
- 18 (15, 16, 17, 19) Ovary transversely oval; one testes nearly round, other
oval.....*L. filiforme biologica* Semenow 1927
Eggs 40 to 43 by 21 to 26 μ . Length of body 3.8 mm. Host, *Pyrrhula pyrrhula pyrrhula*.
- 19 (15, 16, 17, 18) Ovary rounded and triangular; testes longitudinally
oval.....*L. lobatum glandarii* Semenow 1927
Eggs 33 to 43 by 21 to 26 μ . Length of body 4 to 5 mm. Host, *Garrulus glandarius*.
- 20 (14) Ovary smaller than testes..... 21
- 21 (53, 54) Both testes behind ventral sucker..... 22
- 22 (23) Both testes removed from ventral sucker, far to middle of body...
.....*L. porrectum* Braun 1899
Host, *Saurophagus* sp.
- 23 (22) Testes directly behind ventral sucker or at some distance behind it.. 24
- 24 (34) Testes very near ventral sucker..... 25
- 25 (28) Anterior testis adjoins ventral sucker directly..... 26
- 26 (27) Testes nearly round.....*L. lamicola* Layman 1926
Host, *Lanius collurio*, *Upupa epops*.
- 27 (26) Testes transversely oval.....*L. transversum* Travassos 1916
Host, *Tyrannys melanonolicus*, *Megarhynchus pitangua*.
- 28 (25) Anterior testis separated from ventral sucker by coils of uterus.... 29

- 29 (33) Testes and ovary transversely oval..... 30
- 30 (31, 32) Vitellaria in the form of a condensed mass.....
*L. transversogenitalis* subsp. *donicum* Layman 1926
 Length of body 2.2 mm. Host, *Cotyle riparia*.
- 31 (30, 32) Vitellaria in two rows of follicles.....
*L. transversogenitalis* Layman 1922
 (Renamed *L. transversogenitalis* subsp. *turkestanicum* Layman 1926)
 Length of body 4.5 to 4.9 mm. Host, *Cotyle riparia*.
- 32 (30, 31) Vitellaria in form of triangle.....
*L. transversogenitalis sylvestris* Semenow 1927
 Length of body 2.7 to 2.8 mm. Host, *Caprimulgus europaeus*.
- 33 (29) Testes round or nearly so, ovary round..*L. attenuatum* (Dujardin) 1845
 Host, *Turdus merula*.
- 34 (24) Testes some distance from ventral sucker..... 35
- 35 (50) Vitellaria in two rows of follicles..... 36
- 36 (47) Rows of follicles clearly seen..... 37
- 37 (44) Rows of follicles dense..... 38
- 38 (43) Testes round, or nearly round..... 39
- 39 (40) Ovary round.....*L. sinuosum* Travassos 1917
 Host, *Nycticorax violaceus*.
- 40 (39) Ovary transversely oval..... 41
- 41 (42) Vitellaria of both sides fused anteriorly.....*L. alaudae* Layman 1926
 Host, *Alauda arvensis*.
- 42 (41) Vitellaria not fused anteriorly.....*L. rarum* Travassos 1917
 Host, *Coleus flavescens*.
- 43 (38) Testes transversely oval.....*L. vitta* (Dujardin) 1845
 Host, *Apodemus sylvaticus*.
- 44 (37) Follicles not dense, but separated from one another..... 45
- 45 (46) Ventral sucker larger than oral.....*L. donicum* Isaitschikoff 1919
 Host, *Dilichon urbica*.
- 46 (45) Ventral sucker smaller than or equal to oral sucker.....
*L. lobatum* (Railliet) 1900
 Host, *Pica caudata*, *Accipiter nisus*, *Monedula cirrium*.
- 47 (36) Rows of follicles not clearly separated..... 48
- 48 (49) Worms long and narrow, testes longitudinally oval.....
*L. vanellicola* Layman 1922
 Host, *Vanellus leucurus*.
- 49 (48) Worms long, rather broad. The testes transversely (obliquely) oval.
*L. kakea* Bhalerao 1926
 Host, *Corvus insolens*.
- 50 (35) Vitellaria condensed 51
- 51 (52) All genital glands transversely oval.....*L. asovi* Layman 1926
 Host, *Lanius collurio*, *Lanius minor*, *Урұпа ерұс*.
- 52 (51) Testes transversely oval, ovary round, or nearly so.....
*L. magnitestium* Layman 1922
 Host, *Cotyle riparia*.



EXPLANATION OF PLATE XIV

Fig. 1.—*Oswaldoia alagesi*. Fig. 2.—*Lyperosomum papabejani*.

- 53 (21, 54) Anterior testis partly dorsal to ventral sucker, genital glands crowd one another.....*L. olssoni* (Railliet) 1900
Host, *Cypsellus apus*.
- 54 (21, 53) Anterior testis wholly dorsal to ventral sucker.....*L. salebrosum* Braun 1901
Host, *Cypsellus melba*.
- L. parvum*, *L. megastomum* and *L. harrisoni* Johnston (1917) are not included in this synopsis because of lack of the original papers.

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* Assembled by editor for convenience of readers in America.

ON A NEW GENUS OF THE NEMATODA
FAM. ACUARIIDAE SEURAT, 1913*

NADIEJDA SHIKHOBALOVA

The material examined was brought from the isle of Sakhalin by the Sixth All-Union Helminthological Expedition (1928). Seven specimens of *Trypanocorax pastinator* were dissected by the members of Expedition: only one happened to be infested with Nematodes; 9 parasites, 3 males and 6 females, were found in the esophagus of the bird. These parasites possess two lateral lips, a double esophagus, two pairs of cordons at the cephalic end of the body and two alae at the tail extremity of the male. For these reasons they are regarded as belonging to the family Acuariidae Seurat 1913. However they can not be included in the genus *Acuaria* or in any other genus of the same family and are referred to a new genus and species.

Skryabinocerca prima n.gen. n.spec.

Host: *Trypanocorax pastinator*.

Location: Esophagus.

Distribution: The island of Sakhalin.

The body of the parasite is rather small, moderately broad in the middle and gradually tapering towards both extremities. The cuticula is colorless with a delicate transverse striation. Four cordons, straight or slightly convoluted, but never recurved nor anastomosing begin with two at the margin of the mouth, diverge immediately and run backward along the submedian fields of the body. The form of the cordons suggests a thin string delicately striated and hollow inside. Under the microscope one can see that the transverse striation extends through the whole breadth of the cordon. The length of the cordons amounts to one eleventh to one fourteenth of the body length. Usually they end abruptly. Two cephalic papillae on each side, situated on the lateral surface of the body, are noted for their size and their peculiar post-cephalic position. The cervical papillae are very large; viewed laterally they have a tricuspid form; viewed from the ventral surface they protrude sharply laterad. Thin transparent alae with a delicate transverse striation begin immediately behind the cervical papillae, follow the lateral lines and nearly reach the end of the parasite. The lateral line is also sharply marked in front of the papillae, reaching a

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*Recently *Skryabinocerca prima* was found by Goushansky in the esophagus of *Tetrastes bonasia sakhalinensis* from the island of Sakhalin.

point 0.45 to 0.49 mm. distant from the cephalic end of the body (Fig. 1).

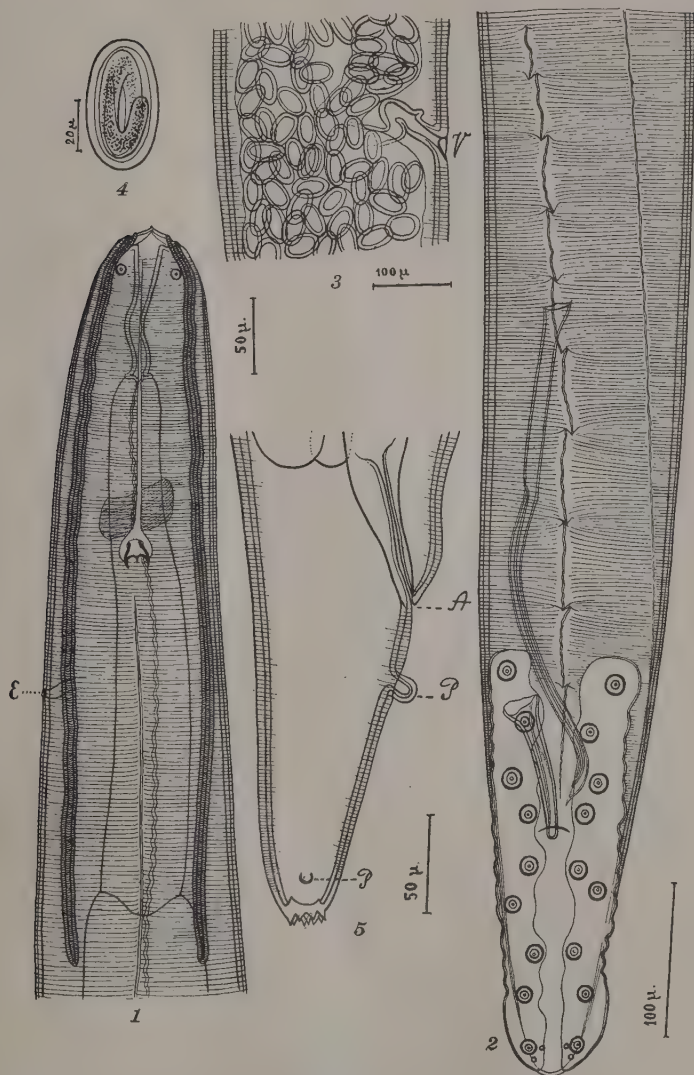
Male. Length 6.22 to 6.58 mm., breadth at maximum 0.219 to 0.230 mm., at end of esophagus 0.201 mm. Post-cephalic papillae situated at a distance of 0.028 to 0.032 mm. from cephalic end of body. Cords 0.427 to 0.441 mm. long, averaging approximately one-fourteenth of total body length, and are about 7μ wide. Cervical papillae 0.235 to 0.277 mm. distant from cephalic end; length, when viewed from median surface of parasite, 0.019 mm.; breadth when viewed laterally, 0.0163 mm. Lateral alae begin just behind cervical papillae and nearly reach proximal end of body; maximum breadth 0.0178 mm. Pharynx 0.114 to 0.13 mm. long by 13μ wide. Muscular esophagus 0.35 to 0.39 mm. long by 62μ wide. Glandular esophagus 1.650 to 2.47 mm. long by 0.120 mm. wide. Caudal alae thin and transparent, about 0.320 to 0.359 mm. long. Cloaca 0.220 to 0.260 mm. distant from posterior end.

There are 9 pairs of rather large caudal papillae, four of which are preanal and 5 postanal. Besides two pairs of small inconspicuous papillae are situated near the first pair of postanal papillae. The other four pairs seem to be grouped by twos. The spicules vary both in size and form. The left spicule, long and thin, shaped in the form of a stiletto and sharply pointed, is 0.390 to 0.395 mm. long by 9μ wide. The right spicule is small 0.120 to 0.130 mm. long and 0.017 mm. broad at maximum, gradually tapering towards its summit and terminating in a rounded tip. Upon the ventral surface of the caudal end of the male is a special cuticular crest, *crista media ventralis* as termed by Prof. Skrjabin. This *crista media ventralis* is about 0.490 to 0.563 mm. long and about 10μ high; it almost reaches the cloacal aperture and has 10 to 12 festoons (Fig. 2).

Female. Length 6 to 6.58 mm., breadth at the level of esophagus 0.246 to 0.27 mm., breadth at level of vulva 0.219 to 0.27 mm., maximal breadth 0.250 to 0.290 mm.

The length of the cords is 0.49 to 0.575 mm., being about one eleventh to one thirteenth of the total length. The breadth of the cords is about 8μ . Some specimens have the ends of the cords slightly bent laterad. In one case one of the cords had a marked tendency to curve laterad and forward and its end was surrounded by a cuticular excrescence formed by a number of small isolated laminae. The cervical papillae are situated at a distance of 0.23 to 0.27 mm. from the cephalic end, their length, when viewed from the ventral surface, reaches 0.026 mm., their breadth viewed sidewise 0.015 to 0.019 mm. The nerve ring is 0.170 to 0.216 mm. distant from the cephalic end, the excretory pore 0.23 mm. from the tip. The lateral alae begin almost immediately behind the cervical papillae their greatest breadth is 22 to

SHIKOBALOVA—NEW GENUS OF ACUARIIDAE



EXPLANATION OF PLATE XV

Abbreviations: *A*, anus; *E*, excretory pore; *P*, papillae; *V*, vulva.

Fig. 1.—Head of *Skryabinocerca prima*.

Fig. 2.—Tail of male.

Fig. 3.—Vulva.

Fig. 4.—Egg.

Fig. 5.—Tail of female.

26 μ . The pharynx is 0.098 to 0.132 mm. long and about 0.013 mm. wide. The muscular esophagus is 0.376 to 0.5 mm. long and about 0.095 mm. wide. The glandular esophagus is 1.83 to 2 mm. long. The vulva has a transverse aperture and is situated at a distance of 1.26 to 1.46 mm. from the caudal end. Lips are never protruding (Fig. 3). Ova measure 49 to 52 μ long by 26 to 29 μ wide (Fig. 4). The anus is 0.16 to 0.196 mm. from the caudal end. At the tip of the caudal end are found 5 to 10 small sharply pointed papillae, gathered in the form of a rosette. Upon the ventral surface of the caudal end of the female is seen a single large, round postanal papilla which is 0.091 to 0.124 mm. from the tip of the tail. Its longitudinal diameter is 13 μ and its transverse diameter 14.5 μ . On the ventral surface at a distance of about 20 μ from the caudal end is another pair of relatively small papillae (Fig. 5).

On the basis of the following features: two lateral lips, two pairs of submedian cordons, two spicules, differing in size and form, two caudal alae with 4 pairs of preanal and 6 pairs of postanal papillae, these parasites are placed in the subfamily Acuariinae Railliet, Henry and Sisoff 1911. Since they possess 4 straight cordons, never recurving nor anastomosing these parasites seem to be closely related to the genus *Acuaria* Bremser 1811, but not as the latter is understood by E. Cram (1927) who classifies parasites of the sub-genus *Cheilospirura* as a special and independent genus. On the other hand the presence of large and peculiarly localized head-papillae, very large cervical papillae, lateral alae running along the body of the parasites, a single large postanal papilla on the ventral surface of the female specimen and lastly the cristae media ventralis on the ventral surface of the males, make it impossible to classify them in *Acuaria* or as any other genus of the same family. It is necessary to refer the parasite to a new genus *Skryabinocerca*, represented by the typical and as yet unique species just described.

Skryabinocerca n.gen.

Acuariinae. The anterior end of the body is provided with 4 submedian cordons, not anastomosing nor recurrent. A narrow pharynx with thick walls; esophagus divided into two parts. The cephalic papillae big and situated on the post-cephalic region. The cervical papillae large, tricuspid. Thin lateral alae begin at about the level of the cervical papillae and almost reach the caudal end of the body. The vulva is situated in the posterior third of the female's body. At the caudal end of a female a number of papillae can be observed in a terminal position, group in the form of a rosette. A single large postanal papilla is situated on the ventral surface at some distance from the caudal end. The male possesses 4 pairs of preanal papillae and two spicules,

unequal in size and form. The parasites are found in the esophagus of the Corvidae.

Type and only species *Skryabinocerca prima*.

Addendum

The author has completed an investigation on the individual variation of *Acuaria anthuris* (Rud. 1819) and the results were submitted to the meeting of the Helminthological Commission on December 19, 1928. The conclusion was reached that *A. anthuris* possesses so called lateral cordons, similar to the lateral cordons of *Acuaria ornata*, described by Gendre (1912). However, the cordons of *A. anthuris* are subject to more or less pronounced variations depending upon the size of the parasite and the thickness of its cuticula. An examination of more than 350 specimens of *A. anthuris* and a careful study of literature concerning *A. anthuris* and *A. ornata* led to the conviction that both species are identical.

The data presented by Williams (1929) in his paper on Specific Characters of the genus *Acuaria* coincide to some extent with these conclusions concerning the occurrence of the so called lateral cordons (pseudo-cordons after Williams) in different species of the genus *Acuaria*; but while he considers the degree of these variations to be valuable for the diagnosis of different species, this study on the contrary showed sharply pronounced variations within a single species.

In conclusion I wish to express my gratitude to Prof. Skryabin for invaluable help rendered me in my work.

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* Assembled by editor for convenience of readers in America.

STUDIES ON THE TREMATODE FAMILY STRIGEIDAE
(HOLOSTOMIDAE). XXI. LIFE-CYCLE AND DESCRIPTION
OF THE CERCARIA OF *COTYLURUS*
MICHIGANENSIS (LaRUE) *

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During the summer and autumn of 1926 and 1927 the life-cycle of a trematode of the family Strigeidae was experimentally followed through the stages of tetracotyle, adult, egg, miracidium, and cercaria. The tetracotyles of this life-cycle, found on and around the hearts of common suckers, *Catostomus commersonii* (Lacépède), were developed into adults in the bursa Fabricii of the herring gull, *Larus argentatus* (Pont.). Adults of the same species obtained from naturally infested herring gulls have been described in a preliminary report by LaRue (1927: 226) under the name of *Strigea michiganensis* LaRue. Since that time Szidat (1929: 612-764) has divided the genus *Strigea* into seven genera. According to Szidat's classification those species of the former genus *Strigea* whose vitellaria are confined to the hindbody and which have a tongue-shaped process projecting into the bursa copulatrix from its antero-ventral wall should be placed in the genus *Cotylurus* Szidat 1929. The adults of the present species possess both of these characters and should therefore now be named *Cotylurus michiganensis* (LaRue).

The tetracotyle of this species was carefully described by Hughes (1928: 415-419) as *Tetracotyle communis* Hughes, a name which falls as a synonym of the earlier name proposed for the adult stage. Hughes found these tetracotyles on and around the hearts of several species of fish, among them the common suckers of Douglas Lake. The tetracotyles employed in my feeding experiments were morphologically identical with those described by Hughes and were also found on the hearts of common suckers of Douglas Lake during the same summer (1927) that Hughes collected his material.

The herring gulls used in these experiments were obtained from their nesting grounds, Goose Island in the Straits of Mackinac, when about two weeks old. They were kept in wire-screened pens on sand and, both before and during the experiments, they were fed cooked fish varied with occasional pieces of fresh beef. The water given them was

* Contribution from the Biological Laboratory of Calvin College and from the Biological Station and the Department of Zoology, University of Michigan. This is the XXI of a series of studies on the family Strigeidae by Professor George R. LaRue, his students and associates.

pumped from a well. In this way the young gulls were protected against strigeid infestations for a week or two before the experimental feedings began. By the time the gulls were three or four weeks old they were large and strong enough to bear heavy infestations. Owing to the parasites which these gulls had obtained while they were still on their nesting grounds a few strigeid eggs were generally found in their feces before the experiments began.

After their removal from the fish the hearts of the common suckers with their tetracotyles were placed in watch glasses and fed to seven young gulls at the rate of about one to three hearts a day for each bird. At the end of two weeks of such experimental feeding two of the gulls died. The other five gulls were killed after being experimentally fed for three to four weeks. The emaciation and paralysis of these gulls, undoubtedly due to their infestations, were symptoms similar to those reported and explained by LaRue (1927:226) for his birds. Upon examination it was found that the bursa Fabricii of every one of my gulls was closely packed with large numbers of mature and immature *Cotylurus*. Other young gulls, not fed materials known to contain tetracotyles, either had only a few *Cotylurus* in their bursae or none at all. The number of *Cotylurus* found in the bursa in each of the seven purposive feeding experiments was so unusually large and included such a gradation of stages of development that there is no doubt that the *Cotylurus* found in the bursae of the experimental gulls developed from the tetracotyles encysted on and around the hearts of the common suckers.

A critical examination of these bursal parasites indicated that they all belonged to one species. Professor G. R. LaRue who had made a careful study of the adults of this species, informed me that he also had found only one species in the bursa Fabricii of his gulls from the same region. Since my adults discussed in the present paper closely resemble the parasites described by LaRue (1927:226) it is believed that all of my specimens obtained from the bursae of the experimentally fed gulls represent *Cotylurus michiganensis* (LaRue).

The eggs used in this study were obtained by slitting open the bursae of the experimentally fed gulls and shaking them in water. The shaking released a large number of eggs and massive concretions containing hundreds of eggs. The concretions were broken up in order to free the eggs. In this way thousands of eggs were quickly and easily collected. The collections of eggs, separated from all other matter, were kept in well-water in labelled watch glasses until the miracidia appeared.

Since only one species of adults was found in the bursae of my gulls, it is believed that the eggs obtained from these bursae also represented only one species. Because the opening of the bursa into the

intestine is small it is improbable that the eggs of parasites living in the intestine would enter the bursa. This is particularly true of the experimental gull whose bursa supplied the eggs that yielded the later developmental stages of the present life-cycle. My record shows that the intestine of this gull contained only two specimens of *Diplostomum* and no other strigeids while the number of *Cotylurus* in its bursa was large. Moreover, only one kind of cercaria was finally obtained from these eggs and this cercaria could readily be distinguished from the cercaria of an intestinal *Diplostomum* of the herring gull. The evidence for this statement will be presented later in connection with the description of the cercaria of *Diplostomum flexicauda* (Cort and Brooks).

Nineteen days after the eggs were collected the miracidia hatched. A study of these miracidia alive revealed that they resembled those of *Diplostomum flexicauda* (unpublished researches) so closely that they are not described here. With the miracidia of *C. michiganensis* five infestation experiments were made involving the following kinds of snails: *Planorbis trivolvis* Say, *Lymnea stagnalis perampla* Walker, *L. lanceata* Gould, *L. emarginata angulata* Sowerby, *Physa parkeri* "Currier" De Camp, *Physa gyrina* Say, and *Planorbis campanulatus* Say. In each experiment three or four snails of different species were exposed together in one watch glass to eight or ten miracidia. Inadvertently a few eggs may also have been transferred with the miracidia to the watch glasses containing the snails. Although the miracidia were carefully watched the actual penetration of a miracidium into a snail was not observed. Thereafter the contents of each watch glass were kept in a labelled bottle with filtered water. The snails were fed lettuce and the water in the bottles was changed every second day.

One of the snails, *L. emarginata angulata* Sowerby, only about half grown, which had been exposed to the miracidia, and possibly also to eggs, on September 4, 1927, produced large numbers of cercariae which were first observed on October 14, 1927, forty days after exposure to the miracidia. This snail was one of a collection of snails obtained from Douglas Lake and kept in an aquarium in the laboratory at least three weeks before it was exposed to the above mentioned miracidia. It could not have become infested in the aquarium since it was kept in well-water and was fed lettuce grown far from the lake. The possibility that this snail was already infested when it was collected is not altogether excluded, but after an examination of the facts presented below appears to be improbable. Of the remaining snails of the collection including the same and other species not one produced the present kind of cercariae. Moreover, the cercariae first appeared forty days after the snail was experimentally exposed to the miracidia and more than sixty days after it was collected from Douglas Lake. Experiments by Mathias (1925:

55) have shown that a period of six weeks was sufficient for the development of the cercaria of *Strigea tarda* (Steenstr.) from its miracidium. Since the weather was unusually warm during the month of September, 1927, there is no reason to believe that a longer period than forty days would be required in this case. This argument is also supported by three other experiments (described in a later paper) which I performed at the same time and in which the cercariae of *Diplostomum flexicauda* (Cort and Brooks) were developed from their miracidia in forty-five days, the snails in these experiments being kept under the same conditions as the snail producing the cercaria of *Cotylurus michiganensis*. From these considerations it seems entirely improbable that the development of the present cercaria from its miracidium required more than sixty days, which would be the case if the snail had been infested before it was collected from Douglas Lake.

If the foregoing discussion of this life-history is correct, the species of cercaria resulting from my infestation experiments is the cercaria of *Cotylurus michiganensis* (LaRue). This cercaria represents a stage of development of the first American life-history in the family Strigeidae which has been experimentally traced through two vertebrate hosts. No attempts were made to infest a common sucker with this cercaria since this fish was not readily obtainable at that time. Consequently, to remove all doubt it seemed desirable to repeat the experiments which connect the various stages of this life-history.

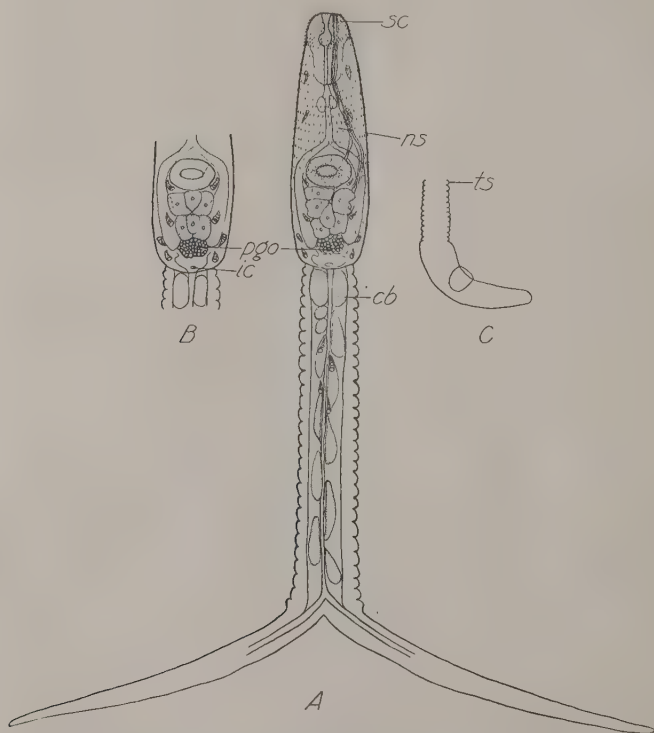
During the summer of 1928 infestation experiments, similar to those of 1927, yielded results similar in every way to the latter. The cercaria obtained in 1928 was specifically identical with that obtained in 1927, but no additional details of life-history or structure were observed. These repeated experiments support the contention that all the above reported stages of *Cotylurus michiganensis* belong to the life-cycle of the cercaria which is here described.

Cercaria michiganensis (LA RUE)

This cercaria, like other cercariae of the family Strigeidae, is a furcocercous form with a pharynx and with an excretory bladder which extends into the tail-stem (Text fig. A). While at rest it assumes a characteristic position (Fig. C). With furcae widely outspread it hangs in the water with the body downward and bent ventrally, the region of greatest bending being near the acetabulum.

This cercaria is small, its total length being about 0.8 mm. when measured alive and free from coverglass pressure. In this condition the body measures 0.22 mm. in length; the tail-stem, 0.30 mm., and the furcae of the tail, about 0.28 mm. Measurements of four specimens, fixed in hot 5% formalin, were 0.22-0.24 mm. for body length, 0.32-0.36

mm. for length of the tail-stem, and 0.24-0.27 mm. for length of the furcae. The body is widest immediately behind the acetabulum where it measures 0.06 mm. The oral sucker is pear-shaped, narrowed posteriorly, and about 0.065 mm. long. The acetabulum, circular in ventral view, is 0.035 mm. in diameter while its dorsoventral dimension is approximately two-thirds of the thickness of the body.



Figs. A, B, C.—Cb, caudal body; ic, island of Cort; ns, nervous system; pgo, primordium of genital glands; sc, spinous cap; ts, tail-stem.

Numerous small spines are arranged over the surface of the body in transversely encircling rows. They are largest, most numerous, and most closely set at the anterior part of the body and more sparsely distributed behind the acetabulum so that their arrangement in transverse rows is less evident there. At the anterior part of the body the first 15 or 16 rows of spines are so close together that they seem to form a

distinct spiny cap, in which the spines have a quincunx arrangement. Six rows of closely set spines surround the opening of the acetabulum while one row is found around its outer margin.

The digestive system is well developed. The dorsal side of the mouth has a projection where the ducts of the penetration glands open. The narrow prepharynx, 0.05 mm. long, is widest immediately in front of the pharynx which is few-celled and spherical, 0.02 mm. in diameter. The esophagus extends more than half way from the pharynx to the acetabulum. Its diameter exceeds that of the prepharynx. The digestive ceca diverge around the acetabulum and extend along the dorsal side of the body almost to its posterior end. Posterior to the acetabulum they are dilated. They contain a uniformly hyaline material.

Three pairs of unicellular penetration glands with coarsely granular contents are arranged typically behind the acetabulum in three longitudinal rows of two cells each as shown in figure B, but their position varies with the contraction states of the animal, one of which is shown in figure A. During contraction of the body the anterior group of these glands may move forward dorsally over the acetabulum. The ducts of the lateral glands extend along the sides of the acetabulum ventral to the digestive ceca, while the ducts of the median glands extend dorsally over the acetabulum. Farther forward these ducts extend together along the sides of the pharynx and through the oral sucker to the anterior end of the body. When stained with thionin it becomes evident that the ducts retain their individuality throughout their course. These ducts are filled with granular contents like those of the glands.

Immediately behind the penetration glands is found a group of cells generally considered to be the primordium of the genital organs. These cells stain deep blue with thionin. According to Szidat (1923:310) the primordium of the genital glands arises *de novo* during the development of the tetracotyle from the cercaria. Szidat's statement raises the question whether the so-called primordium of the genital organs of strigeid cercariae has been correctly named.

The main part of the excretory system consists of a bilobed bladder surrounding an island of Cort. From this bladder two lateral vessels extend anteriorad, one along each side of the body, while a third branch extends posteriorad in the median line of the tail-stem and divides at the posterior end of the tail-stem into two secondary branches each of which extends into a tail-furca. Although these secondary branches have not been traced to their openings, it is believed that each opens near the middle of the dorsal edge of its furca. The lateral vessels have not been traced to the flame cells in which they finally terminate. Eight pairs of flame cells, six in the body and two in the tail-stem, were found in the positions indicated in figure A.

Usually six pairs of caudal bodies containing a pale greenish-yellow fluid substance were found in the tail-stem. Sometimes one of these bodies appeared to be divided into two or more smaller bodies as shown in the figure. Similar bodies of smaller size were also found distributed along the furcae of the tail.

SUMMARY

1. The life-cycle of *Cotylurus michiganensis* (LaRue) was traced by means of infestation experiments.

2. Tetracotyles (*Tetracotyle communis* Hughes 1928) found around the hearts of *Catostomus commersonii*, were fed to young herring gulls, *Larus argentatus*. As a result large numbers of adult *Cotylurus michiganensis* (LaRue) were developed in the bursae Fabricii of the herring gulls.

3. Eggs collected from these bursae produced miracidia in somewhat less than three weeks. Of snails exposed to the miracidia, only two specimens of *L. emarginata angulata* became infested. These two first produced cercariae about forty days after exposure to miracidia.

4. These cercariae differ from other known cercariae by a complex of characters which were fully described.

This study was conducted under the direction of Professor George R. LaRue of the Department of Zoology and Director of the Biological Station, University of Michigan. His kindly interest and helpful suggestions are gratefully acknowledged. I am also indebted to Miss Mina L. Winslow of the Museum of Zoology for identification of the snails.

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GIARDIA HEGNERI N. SP. FROM A PHILIPPINE
CIVET CAT*

H. J. CHU

Among the intestinal protozoa, *Giardia* furnishes fascinating material for study. It has been found among both the lower and higher vertebrates and is cosmopolitan in distribution. The habitat of this intestinal flagellate is usually the duodenum but it occurs occasionally in the jejunum and ileum of the host. The host-specificity of the species in this genus is rigid as indicated not only by morphological characteristics but also by experiments in cross-infection (Hegner, 1926). Up to the present time, few investigators have used an adequate method for determining the systematic relationship of the species in this genus. A method involving statistical studies on the giardias (Simon, 1921; Hegner, 1922) that have been found in various species of animals gives a more scientific basis for identification and classification.

A Philippine Civet Cat, *Viverra zibetha* Gray, recently captured at Dasmariñas, was brought alive into the laboratory. This animal is commonly distributed in the Indian Archipelago and Luzon (Hollister, 1912). An examination revealed a good infection of the duodenum with giardias. The material was fixed and stained by the Schaudinn-iron-haematoxylin method.

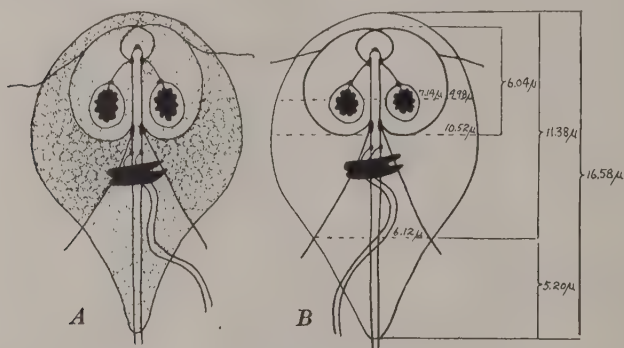
MORPHOLOGY OF THE TROPHOZOITES

In order to determine the species of giardias the following characteristics have to be carefully considered: (1) length and breadth of the body; (2) ratio of length to breadth; (3) distance from the anterior end of the body to the center of the nucleus and from the center of the nucleus to the end of the lateral shields; (4) distance from the end of the lateral shields to the posterior end of the body; (5) distance across the body at the center of the nuclei and at the ends of the lateral shields; (6) the contour of the body, whether narrow or broad at the anterior end and across the lateral shields; (7) distance of the nuclei from the median line and from the posterior edge of the sucking disc; (8) size and shape of the sucking disc; (9) size, shape and location of the nuclei; (10) number, size, shape and location of the parabasal bodies; (11)

* The writer is greatly indebted to Professor Robert Hegner for his valuable instructions and guidance in working out this investigation. Thanks are also due to the Rockefeller Foundation for the grant of a fellowship for study at the University of the Philippines and to the said institution for the facilities afforded for the work.

staining characteristics; (12) infectivity when cysts are fed to experimental animals (Hegner, 1925). Among the above mentioned criteria, the size of the organism as a whole also should be especially emphasized. As a matter of fact, the size of the lower organisms has an important bearing upon their morphology and also on their physiological condition. The studies on *Diffugia* (Jenning, 1916) and *Arcella* (Hegner, 1919) present evidence that size alone can be used as a criterion for determining species.

The *Giardia* from the civet cat possesses the general characteristics of the genus but it is broader than most species across the middle and end of the lateral shields. The length and breadth of the sucking disc are very small as compared with the size of the anterior part of the body. The distance from the anterior end to the center of the nuclei is com-



TEXT FIGURE

A. *Giardia hegneri* n. sp. from a Philippine Civet Cat. $\times 3600$. Camera lucida drawing.

B. Composite diagram based on measurement of 100 specimens.

paratively great largely due to the fact that the nuclei are nearly spherical in shape and lie near the posterior edge of the disc. The "parabasal bodies" are two in number, being quite short, and blunt at one end; they extend diagonally across the axostyles. The tail is very long in proportion to the size of the body. The accompanying camera lucida drawing (Text fig. A) shows the general shape and structure. Measurements of 100 specimens were used to obtain the average from which the "generalized" drawing of the organism was made (Text fig. B). A study of these two figures proves that there are slight differences between a typical specimen drawn with a camera lucida and a "generalized" type drawn from the average measurements of 100 specimens, yet the latter indicates the distinct specific characters of the animal.

The range in body length was found to be 14.3 to 19.7 μ and the mean breadth, 9.98 μ (Table 1). A correlation table showing the length and breadth of the sucking disc is given in Table 2. Measurements were all made from five slides and from twenty specimens taken at random from each.

TABLE 1.—Correlation Table Giving Body Length and Breadth Through Nuclei of 100 Trophozoites of *Giardia Hegneri*

Breadth Through Nuclei	Body Length									
	14.3	14.9	15.5	16.1	16.7	17.3	17.9	18.5	19.1	19.7
7.7	1	..	..	..	..	..	..	..	..	1
8.3	2	4	2	..	2	..	..	..	..	10
8.9	2	2	5	1	3	..	..	..	..	13
9.5	..	2	5	8	5	4	..	..	..	24
10.1	..	2	1	2	7	4	2	1	1	20
10.7	..	..	..	3	4	6	4	1	..	18
11.3	..	..	..	..	1	5	1	1	..	7
11.9	..	..	..	..	..	..	..	..	1	1
12.5	..	..	..	1	..	..	..	..	2	3
13.1	..	..	..	..	..	..	..	..	1	1
13.7	..	..	..	..	..	..	..	..	1	1
14.3	..	..	..	..	..	..	..	..	..	..
14.9	..	..	..	..	..	..	1	..	..	1
	5	10	13	15	22	17	8	8	6	100
	Length								Breadth	
Range.....	14.3 — 19.7								7.7 — 14.9	
Mean.....	16.58 $\pm$ 0.08								9.98 $\pm$ 0.08	
Standard deviation.....	1.19 $\pm$ 0.03								1.28 $\pm$ 0.06	
Coefficient of variation.....	7.17 $\pm$ 0.38%								12.82 $\pm$ 0.70%	
Ratio of length to breadth.....	1.66									

Measurements in all tables given in microns.

TABLE 2.—Correlation Table Giving Length and Breadth of Sucking Disc of 100 Trophozoites of *Giardia Hegneri*

Breadth of the Sucking Disc	Length of the Sucking Disc			
	5.3	5.9	6.5	7.1
5.9	..	5	1	1
6.5	5	13	4	..
7.1	..	23	18	..
7.7	..	7	9	1
8.3	..	1	7	1
8.9	..	2	..	..
9.5	..	..	1	..
Total.....	5	51	41	8
	Length			
Range.....	5.3 — 7.1			
Mean.....	6.04 $\pm$ 0.03			
Standard deviation.....	0.63 $\pm$ 0.03			
Coefficient of variation.....	10.51 $\pm$ 0.55%			
Ratio of length to breadth.....	0.84			
	Breadth			
Range.....	5.9 — 9.5			
Mean.....	7.14 $\pm$ 0.04			
Standard deviation.....	0.71 $\pm$ 0.03			
Coefficient of variation.....	9.96 $\pm$ 0.47%			

According to the present data, *Giardias* have been found in at least ten different species of mammals, a list of which are presented in Table 3. A comparative study of these species is necessary to determine whether or not the *Giardia* from the civet cat is a new species. Certain important characteristics have been carefully considered as follows:

The length and breadth of the *Giardia* from the civet cat is comparatively great. It ranges in length from 19.70 to 14.30 μ and in breadth from 14.90 to 7.70 μ . It ranks next to *Giardia lamblia* in size, with the exception of the mean length, is larger than *Giardia simoni*. The breadth of the body is greater than that of any other species. The lowest breadth is similar to that of *Giardia duodenalis* but the mean breadth is greater. The ratio of body length to breadth is similar to that of *Giardia microti* and quite close to that of *Giardia canis*. An explanation seems to be that the tail of the civet-cat *Giardia* is comparatively

TABLE 3.—Comparison of Length of Sucking Disc, and Ratio of Length of Body to Length of Sucking Disc of *Giardia Hegneri* with Those of Species from Mammals

Species	Authority	Length of Sucking Disc	Ratio of Length of Body to Length of Sucking Disc	Host
<i>G. lamblia</i>	Simon, 1922	5.81	2.22	Man
<i>G. duodenalis</i>	Hegner, 1922b	6.73	2.22	Rabbit
<i>G. muris</i>	Simon, 1922	5.64	1.74	Rat and mouse
<i>G. microti</i>	Simon, 1922	5.27	2.21	Field mouse
<i>G. canis</i>	Hegner, 1922b	6.36	2.11	Dog
<i>G. caviae</i>	Hegner, 1923	4.91	2.15	Guinea-pig
<i>G. caprae</i>	Nieschulz, 1923	6.33	2.21	Goat
<i>G. simoni</i>	Lavier, 1924	7.20	2.39	Rat
<i>G. cati</i>	Hegner, 1925	6.00	2.15	Domestic cat
<i>G. hegneri</i>	Chu, 1930	6.04	2.74	Civet cat

TABLE 4.—Comparison of Length and Breadth, of Trophozoites of *Giardia Hegneri* with Species Found in Other Mammals

Species	Authority	No. of Specimens	Length of Body			Breadth of Body			Ratio of Body Length to Breadth
			Low-est	High-est	Mean	Low-est	High-est	Mean	
<i>G. cati</i>	Hegner, 1925	100	10.50	17.50	12.66	5.25	8.75	6.60	1.92
<i>G. lamblia</i>	Simon, 1922	338	9.25	20.25	13.70	5.00	10.25	7.46	1.84
<i>G. canis</i>	Hegner, 1922b	50	11.90	17.00	13.80	7.60	10.20	8.50	1.62
<i>G. duodenalis</i>	Hegner, 1922b	50	12.70	18.70	15.80	7.70	11.00	9.10	1.73
<i>G. muris</i>	Simon, 1922	250	7.25	12.75	9.75	5.25	9.75	7.25	1.35
<i>G. microti</i>	Simon, 1922	250	9.25	13.25	11.06	5.25	8.75	6.79	1.66
<i>G. simoni</i>	Lavier, 1924	50	14.00	19.00	17.00	7.00	10.50	9.00	1.90
<i>G. hegneri</i>	Chu, 1930	100	14.30	19.70	16.58	7.70	14.90	9.98	1.66

long in proportion to the size of the body. Therefore, the ratio decreases when compared with the body-length as a whole. From the foregoing, it is evident that the size alone of the civet-cat *Giardia* is sufficient to distinguish it from other species that have been found in mammals (Table 4).

Giardia from the civet cat has a peculiar shape due to its great breadth below the sucking disc resulting in a bulging out of the anterior part of the lateral shields. None of the other species possesses this characteristic. The anterior end to the center of nucleus is shorter than that of *Giardia cati* and longer than that of *Giardia canis*. The distance from the center of nucleus to the end of lateral shields is greater than

that of any species. The tail is very long when compared with *Giardia microti*. The breadth across the end of the lateral shields appears to be greater than in any other species.

The sucking disc of the civet-cat *Giardia* is obviously small in proportion to the size of the body. It is smaller than that of *Giardia caprae* and slightly larger than that of *Giardia cati*. The most distinct characteristic of the sucking disc is that the edge of the disc never reaches the margin of the body either anteriorly or laterally. The ratio of length of body to length of sucking disc is greater than that of other mammalian species (Table 3).

As a general rule, the nuclei of the giardias are parallel to the axostyles and near the center of the sucking disc, with the exception of the so-called "bird" type. The nuclei of the civet-cat *Giardia* are more or less in the same location as those of *Giardia caviae*, situated quite close to the posterior edge of the sucking disc. They lie obliquely to the

TABLE 5.—Comparison of Parts of Body of *Giardia Hegneri* with Those of Species found in Other Mammals

Species	Authority	Number of Specimens	Anterior End to Center of Nucleus	Center of Nucleus to End of Lateral Shields	End of Lateral Shields to Posterior End	Breadth Across Center of Nuclei	Breadth Across End of Lateral Shields
<i>G. cati</i>	Hegner, 1925	10	4.60	4.60	3.46	6.60	3.70
<i>G. lamblia</i>	Simon, 1922	10	3.75	5.68	3.62	7.50	3.80
<i>G. canis</i>	Hegner, 1922b	10	4.30	6.00	3.30	8.30	3.70
<i>G. muris</i>	Simon, 1922	10	3.62	4.18	2.00	6.75	3.50
<i>G. microti</i>	Simon, 1922	10	3.37	4.68	3.87	6.60	3.80
<i>G. hegneri</i>	Chu, 1930	10	4.36	6.46	5.16	9.98	5.32

axostyles in which respect they differ from those of any other species in mammals.

The civet-cat *Giardia* has a pair of short, thick, rod-like parabasal bodies, blunt at one end and slightly pointed, at the other, and rarely reaching to the edge of the lateral shields. They lie perpendicular to the axostyle. They appear shorter than those of *Giardia canis* and differ from those of *Giardia cati* in respect to the pointed ends. The pointed ends are forked-shaped, whereas in *Giardia cati* the pointed ends appear to be more distinctly separated.

It is quite conceivable that the giardia in the civet cat may represent an infection from some other animal. The possibility of cross infection from wild monkeys seems possible since they live in the same habitat. A careful study of the giardias of wild monkeys of the Philippine Islands (Hegner and Chu, 1930) indicates that a great difference exists between these and the giardia of the civet cat. It is also improbable that the giardia of the civet cat is a temporary infection of giardias either from wild monkeys or domestic cats. The differences pointed out above

indicate that the giardia of the civet cat is a distinct species heretofore undescribed for which I propose the name *Giardia hegneri* n. sp.

SUMMARY

1. A wild Philippine civet cat, *Viverra zibetha*, from Dasmariñas, Cavite Province near Manila was well infected with giardias in the duodenum.

2. Statistical study shows this to be a new species for which the name *Giardia hegneri* is proposed.

3. The distinctive characteristics of *Giardia hegneri* are great length and breadth of the body; great breadth of the anterior portion of the lateral shields; great distance between the posterior ends of the lateral shields; comparatively small sucking disc, the edges of which lie at some distance from the anterior end and sides of the body; the almost spherical shape of the nuclei and their location near the posterior edge of the sucking disc; two short parabasal bodies, blunt at one end and pointed at the other and a comparatively long tail.

4. No cysts were found.

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STUDIES ON *GLYPHHELMINS QUIETA* STAFFORD*

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Studies of living trematodes in considerable detail constitute the means for a more intimate understanding of the morphology of various organs. Because of the changing relations of organs with contraction and expansion many measurements relating to their position and size do not have the specific significance that authors have often been inclined to give them. A primary object of this work has been to investigate these changing relations with contraction and extension, and also the changes produced in killing, and in so doing to note significant changes, to notice the observable functionings of various organs, and to use the living trematode to advantage in tracing out the complicated structure of the excretory system in detail. Sincere appreciation is here extended to Professor Henry B. Ward whose valued counsel and criticisms have made this work possible.

Glyphelmings quieta Stafford 1900 has been reported in Canada by Stafford from the duodenum and intestines of *Rana catesbiana*, *R. virescens* and *Hyla pickeringii*. Two unreported hosts have been discovered, namely *Rana pipiens* and *R. clamitans*. Fifteen out of fifty-four frogs, mostly *R. catesbiana*, taken near Urbana, Illinois, during the months of June, July, August and September were found to be infected with *G. quieta*. This species has not previously been reported from the United States. Approximately 395 specimens were taken from these fifteen frogs, seventy-one of them from the duodenal and lower intestinal walls of a single *R. catesbiana*.

CHANGES IN ORGANS WITH EXTENSION AND CONTRACTION

Living specimens of *G. quieta* studied in watch glasses and on slides under very slight pressure show surprising ability to elongate, sometimes extending to between two and three times their length when in a contracted condition. During such stages of great extension the usual gourd-shaped or bottle-shaped form is not evident but the worm appears like a long narrow ribbon with uniform width throughout, except at the most anterior end where it is narrower (Fig. 2). Measurements of several body organs of different individuals are proportional only when the individuals are in the same stage of contraction, as such proportions often change during different degrees of contraction of the individuals.

* Contribution from the Zoological Laboratory of the University of Illinois, under the direction of Henry B. Ward, No. 373.

The round oral sucker lies at a distance of about one-fifth its diameter from the anterior end of the body when the living worm is well extended, but this area anterior to the sucker becomes much reduced when the living worm contracts. In the smaller preserved worms this oral sucker measures only about 0.153 mm. in length and 0.189 mm. in width while in the larger specimens it measures about 0.242 mm. in length by 0.283 mm. in width. For twenty preserved worms the average longitudinal diameter of the acetabulum is 0.135 mm. and the average lateral diameter is 0.150 mm. It will be seen that this organ, normally circular in living specimens, is also distorted by the pressure exerted upon its anterior and posterior walls because of contraction. When the body is contracted the acetabulum lies very near to the place of union of the two intestinal crura but with extension the distance from the acetabulum to the union of the intestinal crura becomes about one-half as great as that of the length of the esophagus.

Stafford failed to mention the prepharynx in this trematode, which is not easily discernible in preserved specimens. When food is forced into it, during contraction, the prepharynx expands to as great a width as that of the pharynx or even greater and when the worm is extended the length of the prepharynx becomes nearly as great as that of the pharynx (Fig. 5).

The pharynx is between one-half and one-third as long as the oral sucker and almost two-thirds as wide when in a normal state of contraction. However, after the antero-posterior flattening of the oral sucker when the worm is killed, this proportion is changed and the average of twenty specimens shows the length of the pharynx to be about 0.135 mm. or a little more than three-fifths that of the oral sucker. The pharynx length does not increase or decrease but it is capable of lateral expansion. In mounted specimens the cavity of the pharynx is usually quite narrow, the walls occasionally lying in contact with each other. The extent of the pharyngeal glands along the sides of the esophagus depends upon the amount of contraction of this region.

In living specimens the esophagus, usually almost as long as the pharynx (Fig. 4), may under conditions of great extension reach a length as great as the distance from the union of the intestinal crura to the anterior edges of the two lateral testes. Its length in preserved specimens varies greatly, the amount of contraction showing little correlation to the amount of contraction of the entire worm. An extreme case showing this variation might be mentioned in comparing a small worm measuring only 0.960 mm. in length which had an esophagus 0.059 mm. long with a large worm 1.958 mm. long with an esophagus 0.053 mm. in length.

Each of the two intestinal crura has near its union with the other a sphincter muscle which can entirely close the opening of either crus and

if contraction takes place at the same time as both sphincters close it results in great distension of the prepharyngeal walls or disgorgement of the food through the mouth and cavity of the oral sucker. The crura extend to within a short distance from the posterior end of the body but this distance becomes correspondingly greater during great longitudinal extension. The food-filled intestines of living animals are partially collapsed in preserved animals and the width of the crura becomes noticeably diminished. It is interesting to note that smaller more immature specimens show a much greater proportionate distance between the union of the intestinal ceca and the anterior end of the body (Fig. 6). The acetabulum is in about the center of the body and the reproductive organs are noticeably nearer the posterior end of the body.

The cirrus sac lies on the right side of the acetabulum and normally curves toward the left side of the body in a broad loop, partly encircling the acetabulum. When the worm is at rest the anterior edge of the acetabulum lies anterior to the posterior end of the cirrus sac, but when the body becomes fully extended the cirrus sac becomes straightened out anteroposteriorly with the acetabulum lying to the left of it, with its posterior edge a trifle posterior to a line drawn midway between the anterior and posterior ends of the cirrus sac.

The two slightly obliquely situated, almost spherical testes usually lie in front of the middle of the body. However, in some of the smaller worms which were not so well-filled with eggs, the testes were located noticeably closer to the posterior end than to the anterior. Out of twenty-five mounted specimens examined, eighteen of them showed the testes nearer the anterior end, in four of them the testes were located in the center and in three specimens they were nearer the posterior than the anterior end. The organs measure about 0.20 mm. by 0.18 mm. in preserved specimens and the left testis usually lies slightly posterior to the right one. However it is not uncommon to find specimens with perfectly horizontally placed testes and occasionally the left testis is slightly anterior to the right one. The acetabulum is anterior to them when the body is well extended but its posterior margin extends behind the anterior margin of the left testis when the specimen is contracted (Fig. 1).

The cirrus pouch lies posterior to the union of the intestinal crura at the right of and anterior to the acetabulum, partly encircling this organ but becoming fairly well straightened at times of great body extension. This relation is not stable since the entire cirrus sac may lie anterior to the acetabulum when the worm is well contracted (Fig. 1).

In a normal state of contraction the ovary lies to the left of the acetabulum but when the body is well extended it lies posterior to this organ. In living specimens the ovary is usually spherical, yet in many of the preserved worms it appears roughly triangular or oblong in shape.

The usually spherical seminal vesicle is also often angular in preserved specimens. The passage of the eggs through the metraterm forces apart the walls, which ordinarily are in close contact with each other.

The irregularly shaped vitellaria are located along each side of the body and are usually limited to the region between the union of the intestinal ceca and a point a short distance posterior to the posterior limits of the testes (Fig. 1), lying ventral, dorsal and lateral to the intestinal crura. In occasional specimens vitellaria extend to the pharynx and even past its posterior margin. In the more immature specimens they reach farther posteriorly and in the mature specimens they occasionally extend anteriorly beyond the posterior end of the pharynx. Because of these variations it is evident that the position of the vitellaria is not a fixed characteristic of specific value for this species and it leads me to doubt the advisability of using this character in the specific diagnosis of any form without first having determined the amount of variation of the location of the vitellaria.

THE EXCRETORY SYSTEM

The excretory pore through which the large club-shaped expulsion canal opens to the exterior lies on the ventral side of the body a very short distance from the posterior end (Fig. 7). A few individuals were found in which this pore was located on the margin of the right side of the body near the posterior end. This pulsating expulsion canal extends anteriorly from the pore to within a short distance from the two testes, its length depending upon the state of contraction of the worm. From this point the two large collecting trunks extend diagonally toward the lateral sides of the body. Passing across the testes, each trunk bifurcates near an intestinal cecum into an anterior and posterior collecting tube. Each posterior collecting tube bifurcates in the region just posterior to each testis to send an outer branch beneath the intestine to the area between the crus and outer body wall. Here the outer branch divides into two small tubules, one leading to its terminal cell near the inner posterior margin of the testis while the other branch extends posteriorly and almost immediately divides into two small branches leading to their terminal cells lying between the anterior end of the expulsion canal and the posterior margin of the testis. After having traversed about half the distance to the posterior end of the body each posterior collecting tube again sends a lateral branch to the region between the intestine and body wall. This branch divides in a manner similar to that of the first and ultimately leads to its three terminal cells, one near the anterior end of the expulsion canal and the other two near the central region of the expulsion canal. Near the posterior end of the intestinal crura each posterior collecting tubule gives rise to three small branches which lead

to their terminal cells, one in the region posterior to the center of the expulsion canal, the other two near the posterior end of the expulsion canal.

The two anterior collecting tubules continue in the diagonal course of the two main trunks of the tree-like arrangement of excretory tubules, and each soon bifurcates into a posterior and anterior branch. Each posterior branch divides ultimately into three smaller branches, one leading to its terminal cell in the region of the acetabulum and the other two branches extending to their terminal cells lying also in the region of the acetabulum and testes. Each anterior branch finally redivides into an anterior tubule which continues its anterior direction and a lateral tubule which leads in the usual manner to its three terminal cells in the posterior region of the esophagus and the region of the cirrus pouch and genital pore. Each anterior branch soon divides and redivides to form three small branches which lead to terminal cells in the region near the posterior end of the pharynx, the prepharynx and the portion of the body anterior to the oral sucker respectively.

It will be seen that there is a total of thirty-six terminal cells in the excretory system in the body of this trematode, all of which lie near the midline of the body. Dichotomous branching characterizes the system throughout, although the paired terminal cells scattered along either side of the midline are not always exactly opposite one another. This condition is probably due to minor differences in degree of contraction. The entire system of tubules becomes greatly convoluted when the worm contracts. At times these loops appear first in the region of the terminal cells and undulating movements seem to progress sluggishly toward the openings into the larger collecting tubules. Circular markings or muscle-like rings are evident on the walls of the tubules at times and their action, together with the sluggish movements of the coils and the flickering motion of the vibratile portions of the terminal cells, succeed in forcing the excretory fluids into the two main collecting trunks and finally the expulsion canal. No evidence of cilia lining the walls of the excretory tubules is evident. The shape of the expulsion canal is continually changing, according to the amount of fluid which it contains and the state of body contraction. It becomes drawn out into a long, narrow tube when the worm extends and with contraction becomes compressed into a small irregular sac. As the excretory fluids are poured into the anterior end of this canal from the two main collecting trunks, this end becomes inflated and bulblike in appearance. In a short time its contents are suddenly ejected or expelled down the canal by a sudden winking movement of the canal walls. The excretory fluids collect in the posterior end of the canal in turn and inflate this end into a bladder-like inflation. In a few seconds the contents are expelled through the excretory pore and the anterior end of the expulsion canal again starts to expand.

DISCUSSION

Glypthelmins quieta was first described by Stafford (1900) under the name *Distomum quietum*. Later Stafford (1905) created the genus *Glypthelmins* for it, renaming it *Glypthelmins quieta*. After a detailed study of this form I was struck with the amazing similarity between the excretory system of *Glypthelmins quieta* and that of *Margeana californiensis* Cort 1919. It became a point of great interest to check over the structure of the excretory systems of the two forms and these organs proved to be identical. A study of the two original descriptions together with my own observations makes it evident that *M. californiensis* and *G. quieta* are very closely related.

In his description of *G. quieta* Stafford did not mention a prepharynx, which is barely evident in preserved material. Cort described the esophagus of *M. californiensis* as short, yet he figured the proportionately long esophagus in immature individuals (Fig. 6). Pharyngeal glands were not mentioned in Cort's description of *M. californiensis* while they are present in *G. quieta* and this is the one noticeable difference between these two forms. Stafford described the left testis of *G. quieta* as being slightly posterior to the right one (Fig. 8), while Cort stated that they are both at the same level in *M. californiensis*. A careful examination of many preserved specimens of *G. quieta* reveals a constant variation in the position of the testes. Stafford described the vitellaria of *G. quieta* as occupying the lateral middle half of the body and Cort stated that in *M. californiensis* they reach from the region of the oral sucker to the posterior margins of the testes and has shown them slightly beyond this limit in his drawing (Fig. 9). In *G. quieta* they usually extend from the region of the union of the intestinal crura to a point a little posterior to the testes, but in the more immature specimens they reach farther posterior and in the mature specimens they occasionally extend anterior beyond the posterior end of the pharynx.

I believe the findings of this work constitute sufficient evidence for including *Margeana californiensis* Cort 1919 in the genus *Glypthelmins* Stafford 1905 as *Glypthelmins californiensis* (Cort 1919). This requires the removal from the description of this genus the characteristic referring to the presence of pharyngeal glands. Seven species have been described which belong to the genus *Glypthelmins*. They are given in the following list: *Glypthelmins quieta* Stafford 1900, type species; *Glypthelmins linguatula* (Rudolphi 1819) Travassos 1924 (misspelled *Glypthelmins*); *Glypthelmins parva* Travassos 1924 (misspelled *Glypthelmins*); *Glypthelmins repandum* (Rudolphi 1819) Travassos 1924 (misspelled *Glypthelmins*); *Glypthelmins elegans* Travassos 1926 (misspelled *Glypthelmins*); *Glypthelmins staffordi* Tubangui 1928 (misspelled *Glypthelmins*); *Glypthelmins californiensis* (Cort 1919).

A study of the descriptions of these species shows that some of them do not fit the genus *Glyphelminis* as originally described by Stafford. Obviously then, this genus is in need of revision, but since the type materials are not available it is not wise to attempt a revision at this time.

SUMMARY

Two unreported hosts for *Glyphelminis quieta* are *Rana pipiens* and *Rana clamitans*. This is the first report of this genus from Illinois.

Growth changes and changes in relative positions of organs with contraction and extension are significant.

The excretory system has been worked out in detail and the location of every flame cell ascertained.

Margeana californiensis Cort 1919 has been established as a species of the genus *Glyphelminis* Stafford 1905.

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EXPLANATION OF PLATE XVI

All drawings represent *Glyphelminis quieta* and were made with a camera lucida; in figure 7 the excretory tubules and terminal cells were inserted free hand. The scale in figure 3 represents 0.1 mm.; in other figures it represents 1 mm.

ABBREVIATIONS USED

act, accessory collecting tube; *at*, anterior collecting tube; *c*, capillary; *ct*, common collecting tube; *e*, esophagus; *ec*, expulsion canal; *ep*, excretory pore; *gp*, genital pore; *m*, metraterm; *o*, ovary; *pg*, pharyngeal glands; *pp*, prepharynx; *pt*, posterior collecting tube; *sr*, seminal receptacle; *sv*, seminal vesicle; *tc*, terminal cell; *lt*, left testis.

Fig. 1.—Dorsal view of living adult.

Fig. 2.—Ventral view of fully extended specimen.

Fig. 3.—Section of cuticula from dorsal, middle region of body showing spines.

Fig. 4.—Ventral view of prepharynx of a contracted living specimen.

Fig. 5.—Ventral view of prepharynx of an extended living specimen.

Fig. 6.—Ventral view of immature, living specimen.

Fig. 7.—Dorsal view of living specimen showing excretory system.

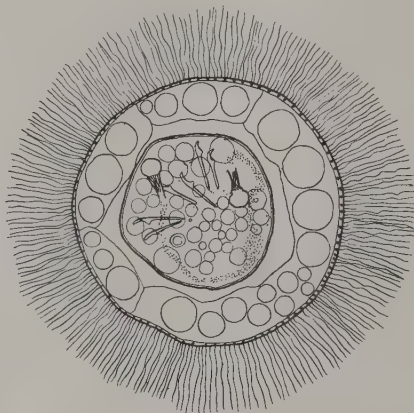
Fig. 8.—*Glyphelminis quieta*, after original by Stafford.

Fig. 9.—*Margeana californiensis*, after original by Cort.

NOTES ON THE HATCHING OF *DIPHYLLOBOTHRIUM*
LATUM EGGS *

LYELL J. THOMAS

Diphyllobothrium latum eggs in water were received from the Mayo Clinic, November 17, 1929, in a tightly corked bottle. They had been removed and concentrated from dog feces by the sieve method two days before. Upon arrival, one cc. of the sediment containing eggs was added to each of twenty-four two inch stender dishes which were kept at room temperature out of the direct rays of the sun. Ground glass covers



Text Figure.—Coracidium of *D. latum* from eggs with delayed development, showing flame cells and hooks in embryo.

were kept on the dishes during the course of the observations. Within twelve days most of the eggs hatched viable coracidia.

Frequent examinations of the remaining unhatched eggs in these same dishes made until January 30, 1930, showed that occasional hatching occurred among these more slowly developing eggs. On this last named date a few coracidia were present in one stender dish and one was observed emerging from an egg. This appeared to be a normal individual (Text Fig.). Upon examination under an oil immersion lens two flame cells 2 by 5 μ were seen which were agitating minute refringent particles nearest them. A few microns away similar particles exhibited

* Contributions from the Zoological Laboratory of the University of Illinois, No. 374.

typical Brownian movement. Although no limiting walls were seen these particles seemed to outline the lumen of a duct. Refrangent granules were noted at the bases of the flagella of the flame cells. As the onchosphere broke up due to the pressure of the cover glass these same cells were noticed to break away intact into the surrounding media. They remained in this condition for a few minutes before disintegrating. Refrangent granules were also seen in the periphery of the ciliated embryophore, apparently at the base of each of the cilia.

The diameters of the coracidia excluding the cilia measured 28 to 29 μ and the diameters of the hexacanth embryos measured 18 to 20 μ . These measurements of the late hatching coracidia seem to indicate that such individuals are apparently smaller in diameter than the normally hatched individuals, as the measurements for normal individuals checked with those of Essex (1927) 24 to 26 μ and those of Janicki and Rosen (1917) 24 μ . The embryophores vary more in their diameters as they increase in size with age. This increased diameter seems to be due to the absorption of water by the embryophore.

From the above data it is evident that in the same batch of *D. latum* eggs under similar conditions there is great variability in the time required for hatching. This condition might give rise to possible infection of copopods for some time after the regular hatching period was over. It might also be one explanation for the variability in size of proceroids within the body of the experimentally infected copopod as has been encountered by the author in other pseudophyllidea and as described by Essex (1927) for *Corallobothrium fimbriatum* and *C. giganteum*.

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TECHNIQUE IN ARTIFICIAL FEEDING OF THE BED BUG, *CIMEX LECTULARIUS* L.

EZEKIEL RIVNAY

Several students, who made a study of *Cimex* species as probable carriers of disease, attempted to feed the bugs artificially, but with little success. André (1912) attempted to feed the bed bugs cultures of pathogenic organisms mixed in bouillon, blood serum and blood; none of them were accepted. He also enclosed the above mentioned mixtures in spherules made of chicken skin, and tried to feed them to the bugs. However, he did not succeed. His own statement reads as follows: "Nous avons essayé d'enfermer du sang frais souillé de microbes dans des petites spherules faites d'épiderme de poulet, mais les *Cimex* ont refusé de piquer autre chose que des animaux vivants." He concluded, in other words, that the bug would feed on nothing but living animals.

Cornwall and La Frenais (1916), in their many futile attempts to feed the bed bug artificially, found that *Cimex rotundatus* refused to feed through parchment or even skin which had been kept in a refrigerator for twenty-four hours. Concluding that the bug would not feed through anything but live skin, they tried the following method:

The end of a glass cylinder, open at both ends, was placed inside the wound formed in a rabbit, close against the cleanly shaven skin. The bugs were placed near the skin from the outside, while the culture of pathogenic organisms with citrated blood was poured through the other opening of the tube. It was believed that the bugs would not feed except on blood. By this technique, the authors claimed they succeeded in feeding the bugs pathogenic cultures. Shrott and Swaminath (1924), followed this technique with satisfactory results. In the foregoing method, however, a host was used, and the technique, it seems to me, was quite complicated:

The present author (1930), in studying the tropisms of the bed bug, *C. lectularius*, succeeded, he believes, in determining some factors governing the feeding habits of this insect. He found, for instance, that the odor of an animal does not act as a stimulus in attracting the bug, but that heat is the major, and perhaps the only, attracting stimulus. The author's experiments have shown that the bed bug will search for a suitable place to pierce any object radiating heat even though such an object be of metal or glass. It was this latter finding that stimulated the author to develop, if possible, a technique of artificial feeding.

There are four main factors to be considered in attempting to feed the bug artificially. These are as follows:

- (1) Heat is the only agent which attracts the bug and stimulates its feeding desire.

(2) The bed bug will not attack any object which emanates a repellant odor, even though that object radiates heat.

(3) The bug will make no attempt to pierce any moist object, nor feed on any exposed liquid.

(4) *Cimex lectularius* will not attempt to pierce too smooth a surface.

EXPERIMENTS

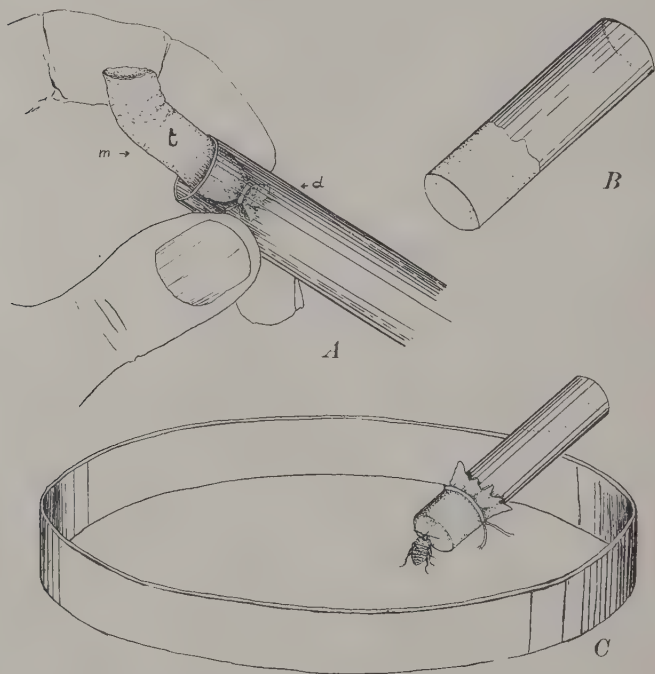
Exp. A. A small piece of rabbit intestine, which had been previously washed and dried, was tied at one end and inflated to form a tube (Text Fig. A, *t*). This tube was filled with filtrated egg albumen and its closed end was slipped into the opening of a small test-tube in which there were two adult female bugs. The test-tube was held near its mouth by the thumb and first finger. Due to the heat of the finger and the thumb, the bugs approached the opening of the tube and stroked the glass with their probosces. By allowing the intestine to rest against one side of the tube, and shifting the finger to that point of contact, the bugs were induced to take notice of the intestine. They made no attempt to pierce or even stroke with their probosces the portion of the intestine above the string (*m*) which was filled with the egg albumen; they did, however, pierce the free end (*d*) of the intestine below the string. The albumen penetrated the intestine wall, causing the external surface of the "tube" to be moist; the wet surface repelled the bug. The free end of the intestine below the string was dry and of the proper texture and was, therefore, attacked. Water was substituted for egg albumen in another piece of intestine, and the procedure repeated. The results were the same.

Exp. B. A portion of shell was removed from a fresh egg so as to expose a small area of thin membrane. The egg was then slightly heated by dipping it partially into hot water. Care was taken that the exposed thin membrane was not immersed. The shell was thoroughly dried, and the egg was placed close to a group of bugs. They approached the egg with extended heads and antennae and upon reaching it, they stroked the shell with the tip of their probosces. The egg was then turned slightly to expose the uncovered membrane. This, the insects treated in the same manner as they had the shell—stroking continuously with the probosces but never actually attempting to pierce. Apparently the membrane was too smooth.

Exp. C. Membrane from a fish intestine was spread in a drum fashion over the opening of a glass tube (Text Fig. B). Through the other opening some warm chicken broth was poured into the tube and filled the drum. This was held in a petri dish wherein there were two adult female bed bugs. The latter were attracted by the heat and advanced toward the tube. However, upon reaching a point about 5 mm.

away from the membrane, they retreated. Apparently the odor of the latter repelled the insects.

Exp. D. The procedure in this experiment is like that in Experiment C, except that the fish membrane was replaced by chicken skin which had been in a refrigerator for several hours, and the adult bugs were replaced by three larvae of the third instar. Attracted by the heat of the chicken broth, they approached the skin, extended their probosces



and began to drill into the skin. They worked in this manner continuously for 3 to 4 minutes changing their positions now and then, as well as their piercing places. Being unable to obtain food, they finally retreated. When the broth, which had been cooled in the tube, was replaced by warmer broth, the above futile attempts were repeated again. Apparently the membrane was too thick and tough for them to pierce through it.

Exp. E. A tender piece of chicken skin, which had been in the refrigerator for several days, was stretched, and its adipose tissue carefully scraped off. This was then spread over the opening of a glass tube as in the preceding experiments, tied with a string, and dried with

blotting paper. Warm chicken broth was poured through the other opening into the tube. This was then placed in a petri dish (Fig. 3), wherein there were three bugs of the third instar. Attracted by the heat of the broth, they approached the tube and began drilling into the skin. In two or three minutes, I noticed the flat abdomen of one of the three bugs becoming inflated. A short while later, after many attempts, the other two bugs also succeeded in getting food, although much less than the first.

Exp. F. Procedures as in the experiment described above, with the exception that a diluted sugar solution stained with Guinea Green B, replaced the chicken broth. The three larvae described in experiment E (one of them having in the meantime molted), approached the warm solution and fed from it sufficiently to render green the intestinal tract which had been visible through the transparent body walls of the insects. The three larvae were kept under observation for a week and were finally preserved in glycerine, when traces of green were still visible in the intestinal tracts. The feces of these larva were greenish brown. The same solution was also fed to two adult females. These, too, were kept under observation and their feces were as described above.

Exp. G. Procedures as in experiments E, with following exceptions: (1) blood serum obtained from fresh chicken blood replaced the chicken broth. This solution was heated slightly so as to prevent coagulation and hardening. (2) One adult female and her progeny, eleven recently hatched larvae replaced the three larvae in the petri dish. The adult female fed to her full capacity, so that her abdomen was exceedingly distended. Nine of the larvae also succeeded in piercing the skin, and fed to their full capacity, thereby becoming a pale pinkish-yellow.

After these successful experiments, several similar feedings were conducted in connection with other problems. These will be discussed in a later paper.

SUMMARY

By taking advantage of the positive thermotropic reactions of the bed bug, this insect was fed on liquids other than blood.

The following factors helped in accomplishing this: The chicken skin employed was very thin and its surface of proper texture; moisture over the skin was blotted out, and all possible sources of repellent odors were removed.

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NOTES ON LARVAL NEMAS FROM INSECTS

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2. *Agamospirura anabri* n. sp. [Figs. 1 to 4 inclusive].

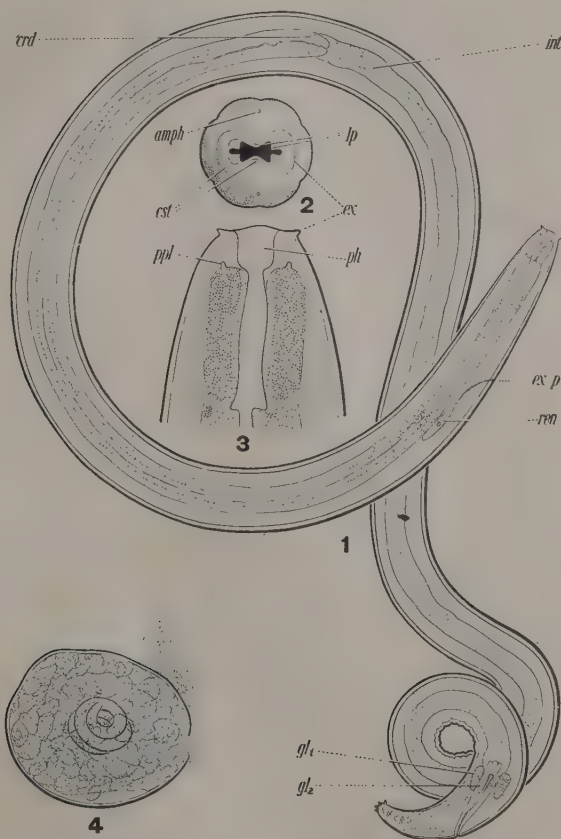
1.4	5.6	49.	Y	96.	2.15 mm.
1.2	1.6	1.8	1.8	1.3	

The cuticula is from 2 to 2.5μ thick, and is traversed throughout by moderately fine, uniform striae, which, when the body is straight, are from 2.5 to 3.5μ apart, except on the extremities of the body, where the annulation is somewhat finer. Fairly well developed alae extend from about opposite, or slightly anterior to the nerve ring, two-thirds the distance to the tail. Anterior to the middle of the body they are about 8μ wide by about 6μ thick near their base, but posterior to the middle of the body they grow increasingly smaller, disappearing entirely in the tail region.

The mouth is elongated dorso-ventrally, and is surrounded by six lips, (*lp*), three on either side, one lateral, one ventro-submedian and one dorso-submedian. Each lip bears on its anterior surface a slight, elongated elevation or crest (*cst*). These do not resemble papillae in general appearance, nor could it be distinctly seen that they are supplied with nerve fibers, although they occupy the same relative position on the head as the lip papillae of *Agamospirura melanopli*. Back on the neck, about 4μ from the anterior extremity (as seen in lateral aspect) are four small, innervated papillae, two dorso-submedian, and two ventro-submedian (*ppl*). Viewed laterally, the head is truncated, and slightly expanded dorso-ventrally at its outer margins. These expansions (*ex*) when viewed from in front, appear as semicircular crests which reach their maximum development on the dorso-ventral axis and become reduced laterally. Near the lateral, outer margin of the head (when viewed from in front) are the small, inconspicuous openings of the amphids (*amph*).

The pharynx (*ph*) is divided into two more or less distinct parts. The anterior portion has a cavity about 5.5μ in diameter and 6μ long, (when seen in lateral aspect). The posterior portion, about 20μ long, has a lumen about 5μ in diameter in the middle, decreasing somewhat in diameter both anteriad and posteriad. This long posterior portion of the pharynx is ensheathed in a heavy wall, which when viewed in optical cross section is broken up into six distinct parts so that it appears six-lobed. The pharynx is unarmed.

The esophagus expands slightly where it joins the pharynx. At the nerve ring it has about one-third the corresponding body diameter, and from this point posteriad it increases in size very gradually until, near the point where it joins the intestine, it has about one-half the corre-



Text Figs.—*Agamospirura anabrii*. 1. Lateral view; $\times 175$. 2. Front view of head; $\times 400$. 3. Lateral view of head; $\times 400$. 4. Cyst, spirally coiled larva within; $\times 37$.

sponding body diameter. While it is not distinctly divided into two parts as was the case with *Agamospirura melanopli*, there is a slight change in its appearance as well as a slight but somewhat abrupt increase in its diameter at a point a little posterior to the excretory pore. Thus it is, no doubt, divided into two parts homologous to those found in some

other spirurid larvae. It is traversed throughout its length by a narrow, but distinctly cuticularized lumen. The esophagus is separated from the intestine by a distinct and rather characteristic cardiac valve (*crd*). At no point, except in the cardia itself, does there appear to be as yet any well developed radiating muscles.

Posterior to the cardia the intestine (*int*) decreases slightly in diameter to about one-third the corresponding body diameter, then increases gradually until, near the rectum, its diameter is a little more than half the corresponding body diameter. It has, throughout its entire length, a comparatively large, uniform lumen.

The rectum is about 50 to 60 μ in length, and has a diameter of 13 to 15 μ at its anterior end, tapering to 4 or 5 μ at the anus. Its lumen is narrow and the wall heavily cuticularized. At the point where it joins the intestine it is flanked by the usual unicellular glands (*gl*). There are probably six of these structures, three larger ones (about 25 μ in length by 10 to 12 μ in diameter) alternating with three smaller ones. Imbedded in the wall of the rectum at its anterior end there occurs at least a pair of unicellular structures, probably also glands (*gl*). In addition there occurs in this region of the body a considerable number of other nucleated structures, but their structure and position can be fully understood only by a careful study of sections.

The tail is conoid, and ends in a rounded terminus armed with six or eight blunt, papilla-like spines, 4 μ long by 3 μ in diameter at the base. When the specimens are killed, the tail is usually curved dorsad with the anus on the outer contour. The excretory pore (*exp*) is located 0.14 mm. from the anterior end, or about 20 μ back of the nerve ring. A conspicuous duct leads to a club-shaped renette gland (*ren*), 35 μ long by 8 μ in diameter.

The larvae are enclosed in a pulpy cyst, a considerable amount of tissue surrounding each spirally coiled nema (Fig. 4). Specimens of cysts furnished the writer measured 0.6 to 0.7 mm., but they were slightly flattened by pressure of the coverglass.

Habitat: From the body cavity of the Mormon cricket, *Anabrus simplex*. The crickets were collected on August 6, 1926, at Bush Creek, Montana, U. S. A., by Mr. Gerald Thorne who very kindly gave the parasites to the writer. Mr. Thorne states that he has several times examined Mormon crickets and has each time found what was probably this parasite.

3. *Agamonema viscosum* n. sp. [Fig. 5].

1.	15.	23.	Y	85.	1.02 mm.
1.8	4.	5.	5.1	3.	

The cuticula is thin, colorless, and traversed by fine transverse striae, which are resolved with difficulty. Longitudinal striation due to the attachment of the muscles is visible. The head is rounded and set off by a broad, shallow constriction. The neck region is conical throughout, the taper increasing gradually anteriad. Slightly posterior to the middle, the body decreases very gradually in diameter, the taper becoming slightly more abrupt in the region of the anus and extending out into a conical, pointed, unarmed tail. The pharynx is composed of an anterior portion (*ph*) which is probably a narrow tube, and a more conspicuous and somewhat complicated basal portion, which has a diameter about one-fifth the corresponding body diameter and is a little longer than wide. The greater diameter of the conspicuous oblong amphidial markings (*amph*) is about one-fifth the corresponding diameter of the neck, and when the specimen is seen in lateral view, overlap and somewhat obscure the basal portion of the pharynx. In general, the relatively long, slender esophagus (*oe*) is rhabditoid in shape. It has well developed median and cardiac bulbs, neither of which seems to possess a valvular apparatus. The nerve ring (*nrvr*) encircles the esophagus about midway between the two bulbs. The excretory pore (*pe*) is conspicuous, and lies opposite the cardiac bulb. An excretory duct extends inward, then turns posteriad, and can be traced for only a short distance. Back of the cardiac bulb the intestine increases in size rather gradually until it occupies about two-thirds the space in the body. It continues to occupy this space throughout its length, decreasing slightly as the diameter of the nema decreases. It is pushed dorsad by the genital rudiment which is small and composed of very few cells. The anus is not salient.

Habitat: Found in large numbers adhering to the outer surface, largely under the elytra of a dung beetle *Geotrupes* sp. They are covered with an oil-like substance which causes them to float on the surface of water, and stick to each other and to the surrounding debris. They will live for many hours when mounted in water on a slide, and exhibit marked resistance to killing fluids.

4. *Agamonema migrans* n. sp. [Fig. 7].

3.2	15.4	28.	Y	82.	.45 mm.
2.4	5.	6.	6.	4.4	

The colorless cuticula possesses very faint transverse striae, while longitudinal striae due to the attachment of muscles are more easily seen. The head is rounded and set off by a long, shallow constriction. The body tapers gradually from the middle to the tail without abrupt changes at any point, and ends in a sharply pointed terminus. The pharynx (*ph*) is long and cylindrical, about twice as long as the head is wide. At its base it appears to have the sort of glottoid apparatus peculiar to rhab-

ditids. As seen in profile, the mouth is set off by two, very small cuticularized structures. The small, circular amphideal markings (*amph*) are quite conspicuous, and are placed back of the mouth opening a distance about equal to half the head diameter. The esophagus (*oe*) is typically rhabditoid, and with the suggestion of an anterior, pharyngeal bulb. The median and cardiac bulbs are about equal in size, but only the latter possesses a valvular apparatus. The inconspicuous nerve ring (*nrv r*) encircles the esophagus about half way between the bulbs, or possibly slightly anterior to this point. The conspicuous excretory pore

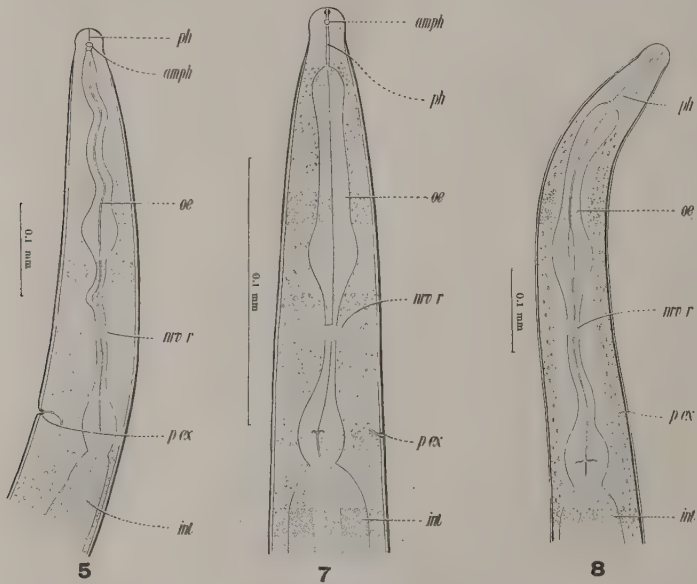


Fig. 5.—*Agamonema viscosum*.

Fig. 7.—*Agamonema migrans*.

Fig. 8.—*Agamonema infestans*.

(*p ex*) is located opposite the cardiac bulb and a duct extends inward, then bends backward and can be traced for a short distance. The genital rudiment is fairly well developed, consisting of a string of fifty or more cells and occupying a position slightly posterior to the middle of the body. The intestine is moderately packed with granules of various sizes, and the intestinal lumen can be seen throughout most of its length. The rectum curves ventrad, then abruptly alters its course, and curves a second time, and is thus divided into two rather distinct parts. The anal opening is indistinct and not set off in any manner.

Habitat: Found under the elytra of the beetles *Tachinus flavipennis* and *Geotrupes splendidus*, collected October 29, 1924, at Falls Church, Virginia, on decaying fungi.

5. *Agamonema infestans* n. sp. [Fig. 8].

3.5	14.6	21.	Y	77.	2.6 mm.
2.5	4.	4.6	4.8	2.7	

The cuticula is thin and colorless and no doubt traversed by exceeding fine transverse striae but the writer was unable to resolve them. The head is rounded and distinctly set off by a broad, shallow constriction. The body tapers slightly throughout the neck region, the taper becoming a little more abrupt near the head. From slightly posterior to the middle, the body tapers gradually and without abrupt change, to end in a conical, pointed tail. Amphids were not seen. The pharynx (*ph*) is nearly three times as long as the diameter of the head and has a broad lumen which increases slightly in diameter posteriad. The rhabditoid esophagus (*oe*) has a rather pronounced anterior enlargement back of which it is relatively rather slender. The lumen expands pronouncedly in the median bulb but this can not, strictly speaking, be regarded as a valve. The cardiac bulb, which about equals the median bulb in size, has a well developed valvular apparatus. The nerve ring (*nr*) encircles the esophagus slightly anterior to a point half way between the two bulbs. The excretory pore (*pe*) opens at a point about opposite the anterior end of the cardiac bulb. The intestinal cells are large, filled with more or less spherical granules of varying sizes, and have a yellowish tinge. The lumen is easily seen, zig-zags slightly and is somewhat expanded at its anterior end. The genital rudiment is located at about the beginning of the posterior third of the body (latitude 65). It is spindle shaped, about one and one-half times as long as the body diameter at this point, and is composed of about 8 to 10 cells. The rectum is a fine, thin walled tube about one and two-thirds times as long as the anal body diameter. The anus is small and not set off in any way.

Found in enormous numbers on the surface of an unidentified Silphid beetle belonging to the genus *Necrophorus* collected on carrion at Falmouth, Massachusetts, August 30, 1926. The larvae were clustered in thousands under the elytra and on other protected parts of the body of two out of five beetles examined. The larvae were all approximately the same size and same stage of development. They lived and were active for five minutes under the influence of osmic vapor.

Nematologists have, for a long time, been familiar with *Rhabditis coarctata*, Leuckart, and its habits of forming cysts on the outer surface of dung beetles in order to affect a safe transfer from one habitat to another. The rhabditid-like larvae described above were without much

doubt on beetles for the same purpose. Somewhat less efficiently protected against desiccation and other adverse conditions, they are nevertheless, covered with an oil-like substance, which probably serves in this capacity. The remarkable resistance of these larvae to such active killing reagents as osmic vapor or Flemming's strong fluid seems to bear out this point. The three species here mentioned are but examples of a vast number of insect-carried rhabditid-like nemas. They are often found on beetles which frequent decaying organic matter and very likely occur on other insects. In addition to the rôle they play as secondary hosts for a great number of parasitic nemas, insects must also play an exceedingly important rôle as vectors in the transportation and dissemination of free-living and plant infesting species.

BOOK REVIEWS

INTRODUCTION TO HUMAN PARASITOLOGY. By ASA C. CHANDLER. 655 pp., John Wiley & Sons, New York.

While the work in hand is listed as the fourth edition of Chandler's well known and highly valued work it is in reality not only thoroughly revised but entirely rewritten and the material is organized from such a different point of view that it should be regarded as a distinct work. Chandler's *Animal Parasites and Human Diseases* under which title the first three editions were issued as the author states "was designed to set forth the important facts of human parasitology in a form which was sufficiently non-technical, and sufficiently readable, so that it would be both useful and stimulating to a wide range of readers." There is no field in which scientific investigation has advanced into the unknown more rapidly than in parasitology and general ignorance even among educated men and women of the important discoveries in this field and their relation to preventive medicine is most deplorable. Yet it is not more conspicuous than the attitude of a considerable percentage of the public towards medical science in general. However, Chandler has found that his desire to educate the public has not been realized.

On the other hand the adoption of the work for college teaching has led to the preparation of this revised edition for the specific purpose of making it appropriate as a text for those preparing to enter the practice of medicine or work in public health. While at first parasitology was treated in somewhat brief fashion as an adjunct to bacteriology it is now beginning to assume its rightful position in the college curriculum and the new edition has been worked out with reference to that relation. The three main sections deal with Protozoa, Worms, and Arthropods and have been grouped with regard to their location in the body of the host rather than regarding to their zoological relationships. Classification has been almost entirely omitted and special emphasis laid on the biological aspects of the subject. The work is most comprehensive and is on the whole well balanced although each teacher will have his own ideas with regard to the emphasis which should be laid upon individual parts of this subject. One must acknowledge that there are very few books covering these three rather distinct and frequently separated fields with such success as is evidenced in the present work. The text is exceedingly readable and the work should appeal not only to teachers but also to medical workers and to the better class of general readers.

GUIDE TO THE STUDY OF ANIMAL PARASITES. By WILLIAM A. RILEY and REED O. CHRISTENSON. 131 pages, 33 figs. New York.

In the extensive series of texts on animal parasitology which have appeared within recent years and which have been subject to review in these pages there has been little or nothing to provide for the direction of laboratory exercises in connection with the study of the subject. While many institutions have introduced courses in parasitology the work has suffered such rapid change by virtue of the growth in knowledge and material available that a laboratory syllabus has hardly been reduced as yet to formal shape. Professor Riley's work in this field has been generally recognized as that of a leader and the appearance of the laboratory guide prepared under his direction naturally would be welcome. The work in hand deserves high praise. It is brief enough to fall within the scope of the ordinary college course. It is well balanced, thoroughly up-to-date in its treatment and written in a form sure to be intelligible and interesting to college students.

The work is well printed and the figures for the most part new and good though a few are distinctly below the standard of the rest. In the references which as a rule are well selected the reviewer could not help being struck by the

omission from those on technique of the classic paper by Looss which was translated and republished in this country by Kofoid. Despite the fact that this is more than twenty-five years old it handles the subject in more satisfactory fashion than any of the modern revisions. Typographically the work is attractive although one sees medievalisms like the use of diphthongs in scientific words and not infrequent typographical errors which will doubtless be corrected in an early revision. It is difficult to justify or even explain the use of quotation marks in connection with certain titles in the list of references. These give to the page a strange and rather clumsy appearance. One feature of high value to laboratory workers is the carefully selected lists of internal parasites found in common laboratory animals.

LE TRACHOME. By A. CUÉNOD and R. NATAF. 238 pp., 39 figs. Masson & Co., Paris.

As emphasized by Professor Nicolle in the preface written for this work the long experience of the author, the terrible frequency of trachoma in Tunis, and the value of the experiments made to determine its nature and cause are more than adequate to call for a cordial welcome to this work. The question of trachoma is one of the most complex and confused of all in literature and while the views that prevail with reference to the causal organism are extremely diverse and are discussed at times with more force than actual evidence, any intensive study of the situation must be welcomed by students of human diseases. The relation to animal parasitology is certain at least in good part as regards the transmitting agents. Readers will find in this work a brief but very clear section on the rôle of flies and the resistance of the virus to conditions of temperature, drying, etc., that affect its virulence in the variably period that intervenes between contamination and reaching another possible host. One can only hope that all of the investigations and experiments outlined herein will be prosecuted vigorously in the near future for the disease is one that affects very directly our international relations through immigration laws.

CONGRÈS INTERNATIONAL DE MÉDECINE TROPICALE ET D'HYGIÈNE. Comptes rendus. By M. KHALIL, Secrétaire Général du Congrès.

The International Congress of Tropical Medicine and Hygiene which was held in Cairo, Egypt, during December, 1928, has issued already two volumes of proceedings. The first is concerned with the organization of the congress. The second deals with the history of medicine, internal medicine, and pediatrics. In the section devoted to the history of medicine there are several very interesting papers on early Egyptian medicine and the papyri that give our earliest records of human parasites. In the section on internal medicine the material on spirochetosis and trypanosomiasis will appeal especially to parasitologists. Further publications will probably contain more material in this field and will be awaited with great interest.

NECROLOGY

The distinguished teacher and investigator in parasitology, Doctor Max Braun, Professor of Zoology at the University of Königsberg, died on February 19 at the age of 80. His contributions to the literature of parasitology were so extensive and valuable that he was known almost personally to nearly every worker in the field and was rightly held in high esteem by all. The JOURNAL hopes at an early date to be able to publish an appropriate sketch of his life and work.

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The actual dates of the issue of Volume XVI of the Journal were as follows:

No. 1, October 22, 1929	No. 3, April 5, 1930
No. 2, December 3, 1929	No. 4, June 25, 1930

